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BOLESŁAW SUSZKA

Cold storage of already after-ripened beech (*Fagus silvatica* L.) seeds

INTRODUCTION

Beech seed * when dried to about 10% of water content in their fresh weight can be stored successfully for a longer time in sealed containers at temperatures below 0°C (Nyholm, 1954, 1960; Messer, 1960; Buszewicz, 1962b, 1964; Schönborn, 1964; Machaniček, 1965; Vlase, 1968). In earlier papers (Suszka, 1966, 1974) the author reported on the storage of beech seed originating from the lowlands of Poland, which after 4 winters at −10°C have lost only about 20% of their initially very high (98%) germinative capacity. Seeds from the Polish Carpathians from an elevation of 900 m were stored over 5 winters in the same conditions loosing during that time 34% of their initial (80%) germinative capacity. The lowland seeds for these experiments were collected immediately after falling off the trees which made it possible to estimate their real after-ripening requirements. These latter seeds when stratified immediately at different constant temperatures in the range 1° - 5°C germinated from the 90th till the 150th day of cold stratification. Seed stored for 2 - 4 winters germinated during cold stratification somewhat later, but the length of the germination period (50 - 60 days) at 1° or 3°C did not change. A transfer of these seeds to a higher temperature (20°C) at the time when the first radicles began to appear caused a serious reduction of the germinative capacity. Seeds originating from the mountains collected early after seed fall began to germinate already after about 35 days when stratified at 3°C. Here also the germination period was as long as in the case of the lowland provenance despite the earlier onset of germination.

Other authors used for their work mostly beech seed already partially after-ripened during stocking or partial drying in the cool thermal conditions of late Autumn or early winter. They proposed very different lengths of the stratification period before sowing necessary for their ger-

* The term "seed" used in this paper concerns always whole beechnuts.

mination extending from some weeks to some months (Rohmeder, 1951).

The question which we tried to solve was to find whether it is possible to after-ripen beech seed before storage and to store them in this state. We hoped that a partial after-ripening would allow a shortening of the germination period which is usually long in the case of seeds stored immediately after collection followed by partial drying.

For this reason two experiments were arranged both begun with seeds collected on the day they fell off the trees. In the first experiment the seeds were stratified immediately and at regular intervals successive samples of seeds were partially dried and stratified again either immediately or after a period of cold storage. In the second experiment the seeds were maintained at their initial high water content level during chilling without any medium and at regular time intervals samples were stratified or partially dried and treated as in the first experiment. The general aim of this work was to find better ways of preparing beech seed for germination and for storage than are already known.

MATERIALS AND METHODS

The seeds were collected in Autumn 1973 in the Kórnik Arboretum (Kórnik near Poznań, Poland) immediately after seed fall from 5 fruiting trees. Afterwards the empty and damaged seeds were removed and all the remaining seed material was throroughly mixed and used for the experimental work immediately.

The water content of seeds was estimated by weighing before and after drying at 105°C for 24 hours. All data concerning water content given in this paper is calculated on the fresh weight basis.

The initial viability of seeds was estimated using 4 different methods:

1) the cutting test,
2) the indigocarmine (1 : 2000, 1 hour at 20°C) embryo staining test,
3) the germination test on moist filter paper at 3°C (whole nutlets),
4) the stratification test (peat/sand 1 : 1 medium) at 3°C (whole nutlets).

In the latter two tests the seeds were checked at 14 day intervals. Seeds with radicles longer than 3 mm were considered as germinated and were removed after each checking together with moulding or decaying seeds.

Stratification of seeds from the different experimental variants was performed like in the viability test 3 in the moist sand/peat medium at 3°C with the same checking procedure as that described above.

Rapid drying of seeds was performed at 18° - 19°C, the seeds being spread out as a thin layer in an air stream of a ventilator fan. The drying time never exceeded 48 hours.

After the end of each stratification the viability of the remaining non--germinated seeds was tested using the cutting test.

Each stratification variant was replicated 4 times, with 50 seeds in each replication. For each estimation of water content 3 replicates were used with 30 beechnuts in each of them.

Experiment 1

The nuts were collected on September 24th 1973, the experiment was begun on the next day. The design of the experiment is shown on Fig. 1.

Immediately after collection the seeds were tested for their water

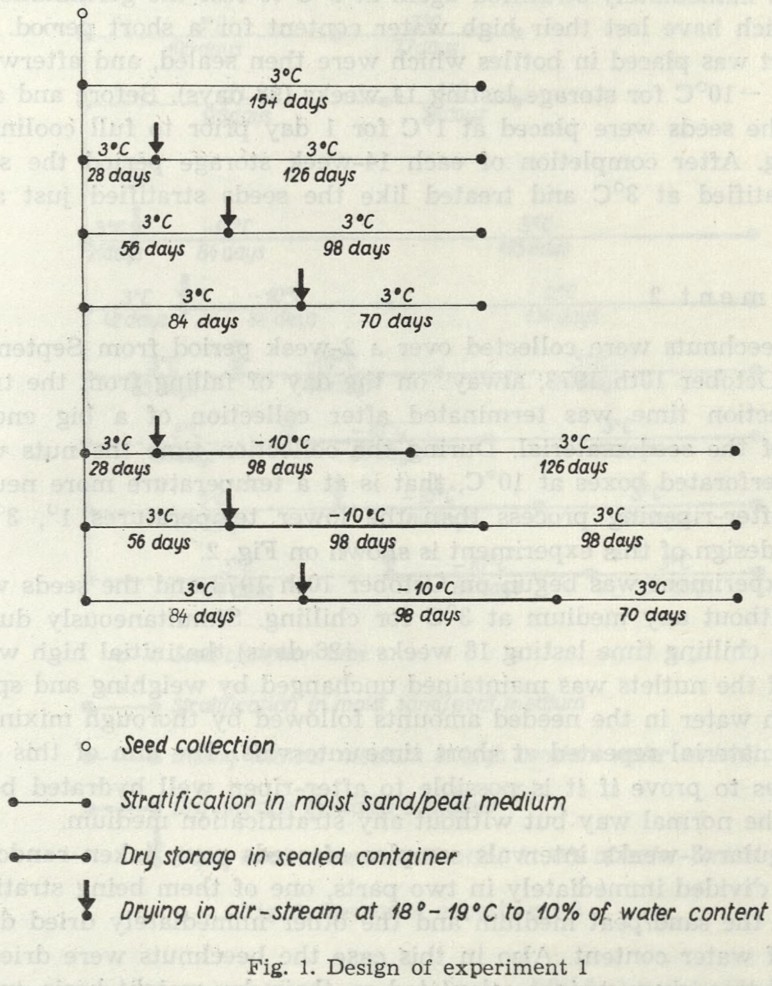

Fig. 1. Design of experiment 1

content, their viability was estimated and the germination tests were begun. All the remaining seeds were stratified at 3°C. At regular 4 weeks (28 days) intervals samples were collected and dried instantly at 18°

- 19°C to 10% of water content, the weight of the partially dried seeds was calculated earlier using their initial dry weight as basis for the calculation. Also the water content of each sample was estimated in the normal way (drying at 105°C and weighing) just before and just after the termination of drying at 18° - 19°C to the calculated point. The difference between the calculated and the estimated values did not exceed 0.5% of water content.

The last sample to be dried to 10% w.c. was collected in the 12th week of stratification (after 84 days) when the first radicles began to appear. The drying always lasted about 48 hours. After having reached the 10% level of water content each sample was divided into two parts. One of them was immediately stratified again at 3°C to test the germination of seeds which have lost their high water content for a short period. The other part was placed in bottles which were then sealed, and afterwards placed at −10°C for storage lasting 14 weeks (98 days). Before and after storage the seeds were placed at 1°C for 1 day prior to full cooling or defrosting. After completion of each 14-week storage period the seeds were stratified at 3°C and treated like the seeds stratified just after drying.

Experiment 2

The beechnuts were collected over a 2-week period from September 26th till October 10th 1973, always on the day of falling from the trees. The collection time was terminated after collection of a big enough amount of the seed material. During the collection time the nuts were held in perforated boxes at 10°C, that is at a temperature more neutral for the after-ripening process than the lower temperatures 1°, 3° or 5°C. The design of this experiment is shown on Fig. 2.

The experiment was begun on October 10th 1973 and the seeds were placed without any medium at 3°C for chilling. Simultaneously during the whole chilling time lasting 18 weeks (126 days) the initial high water content of the nutlets was maintained unchanged by weighing and sprinkling with water in the needed amounts followed by thorough mixing of the seed material repeated at short time intervals. The aim of this procedure was to prove if it is possible to after-ripen well hydrated beech seeds in the normal way but without any stratification medium.

At regular 3-weeks intervals samples of seeds were taken randomly and were divided immediately in two parts, one of them being stratified at 3°C in the sand/peat medium and the other immediately dried down to 10% of water content. Also in this case the beechnuts were dried at 18° - 19°C to a given weight calculated on their dry weight basis, which practically did not change during the chilling time. Only at the onset and at the end of the chilling time the normal water content estimation was performed, showing in the last case that there was no difference between

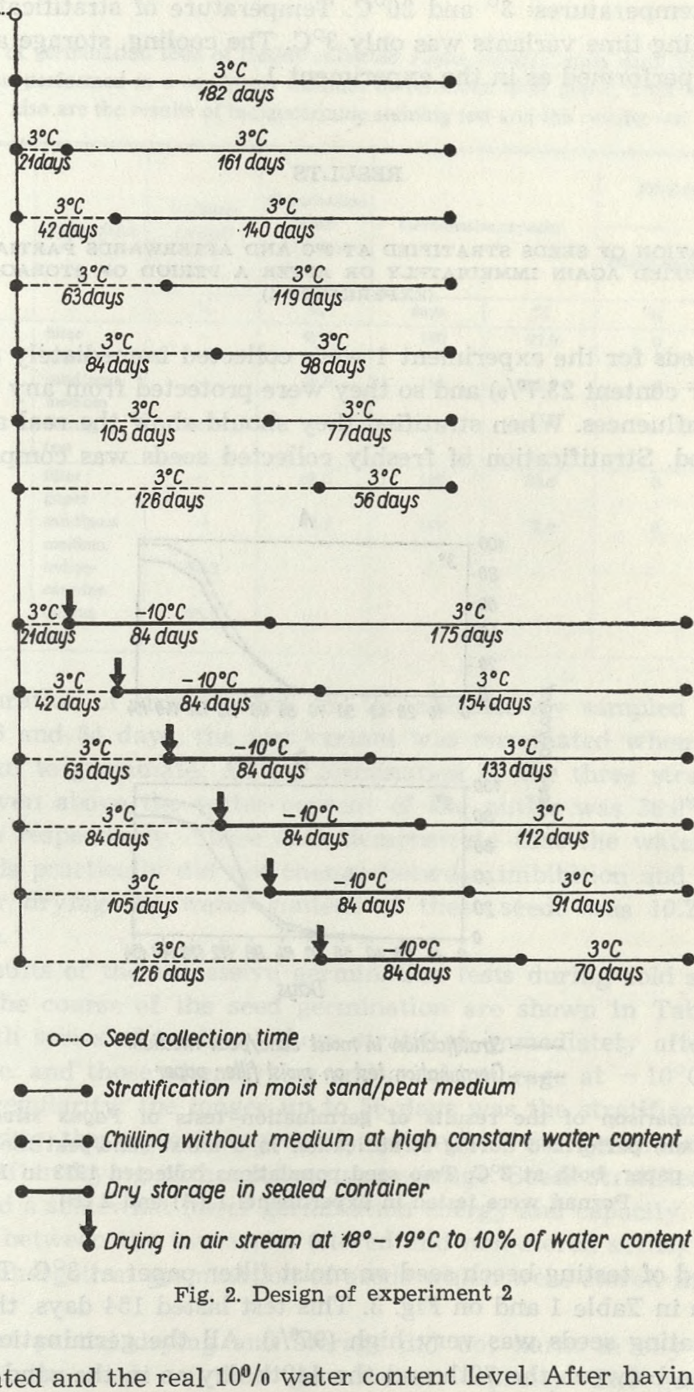

Fig. 2. Design of experiment 2

the calculated and the real 10% water content level. After having reached the planned low level of hydration these seeds were stored for additional 12 weeks at -10°C. Only in the variant with 18 weeks of chilling followed by drying and storage the seeds were stratified after storage at both the temperatures: 3° and 20°C. Temperature of stratification in all other chilling time variants was only 3°C. The cooling, storage and defrosting was performed as in the experiment 1.

RESULTS

A. GERMINATION OF SEEDS STRATIFIED AT 3°C AND AFTERWARDS PARTIALLY DRIED AND STRATIFIED AGAIN IMMEDIATELY OR AFTER A PERIOD OF STORAGE AT —10°C (EXPERIMENT 1)

The seeds for the experiment 1 were collected immediately after seed fall (water content 23.7%) and so they were protected from any unwanted thermal influences. When stratified they should show the real after-ripening period. Stratification of freshly collected seeds was compared with

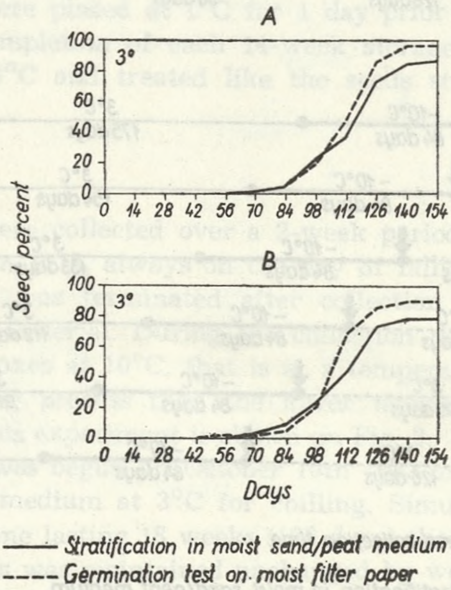

Fig. 3. Comparison of the results of germination tests of *Fagus silvatica* seeds. The tests were performed during stratification in a moist sand/peat medium or on moist filter paper, both at 3°C. Two seed populations collected 1973 in Kórnik near Poznań were tested in experiments 1 (*A*) and 2 (*B*)

the method of testing beech seed on moist filter paper at 3°C. The results are shown in Table 1 and on Fig. 3. This test lasted 154 days, the percent of germinating seeds was very high (97%). All the germination occured in the time between the 70th and the 140th day as in the sand/peat stratification medium, but more energetically and more uniformly. Another advantage of the filter paper method was easy access to the seeds and much less labour during seed checking.

Table 1

Comparison of germination tests of freshly collected *Fagus silvatica* seeds used for experiments 1 and 2 when performed in a sand/peat medium or on moist filter paper, both at 3°C. Given also are the results of indigocarmine staining test and the cutting test

No. of the experiment	Type of test	Viability (initial)	Germination after 112 days	Germinative capacity		Final cutting test	
						empty seeds	decayed and or insect damage
		%	%	days	%	%	%
1	filter paper	–	49.5	140	97.0	0	3.0
	sand/peat medium	–	38.0	154	85.5	0	14.5
	cutting test	90.0	–	–	–	–	–
2	filter paper	–	68.5	140	88.5	0	11.5
	sand/peat medium	–	44.5	140	78.0	0	22.0
	indigo-carmine	94.5	–	–	–	–	–
	cutting test	95.5	–	–	–	–	–

The duration of stratification for the successively sampled seed lots was 28, 56 and 84 days, the last variant was terminated when the first seeds began to germinate. At the termination of the three stratification periods given above the water content of the nutles was 36.6%, 35.1% and 36.2% respectively. These data demonstrate that the water content of the seeds practically did not change between imbibition and germination. After drying the water content of these seeds was 10.2%, 9.5% and 10.2%.

The results of the successive germination tests during cold stratification and the course of the seed germination are shown in Table 2 and Fig. 4. Both series of seeds — those stratified immediately after drying to 10% w.c. and those after drying and a cold storage at −10°C showed the same regularity: the longer up to 56 days was the stratification time before drying the more energetically proceeded the germination after drying or after drying with a subsequent storage. Seeds stratified 84 days already had a somewhat lower germination energy and capacity. The only difference between the two series (stored and non-stored seeds) consisted in a more energetical germination of seeds which were stored in the frozen state.

The fast partial drying and storage did not harm in any way the viability of the seeds or their germination capacity. The germination period was shortened in the best variants to 42 instead of 70 days as in the case of the non-treated seeds. It followed immediately the onset of the stratification after drying or after storage in the dried state. Specially

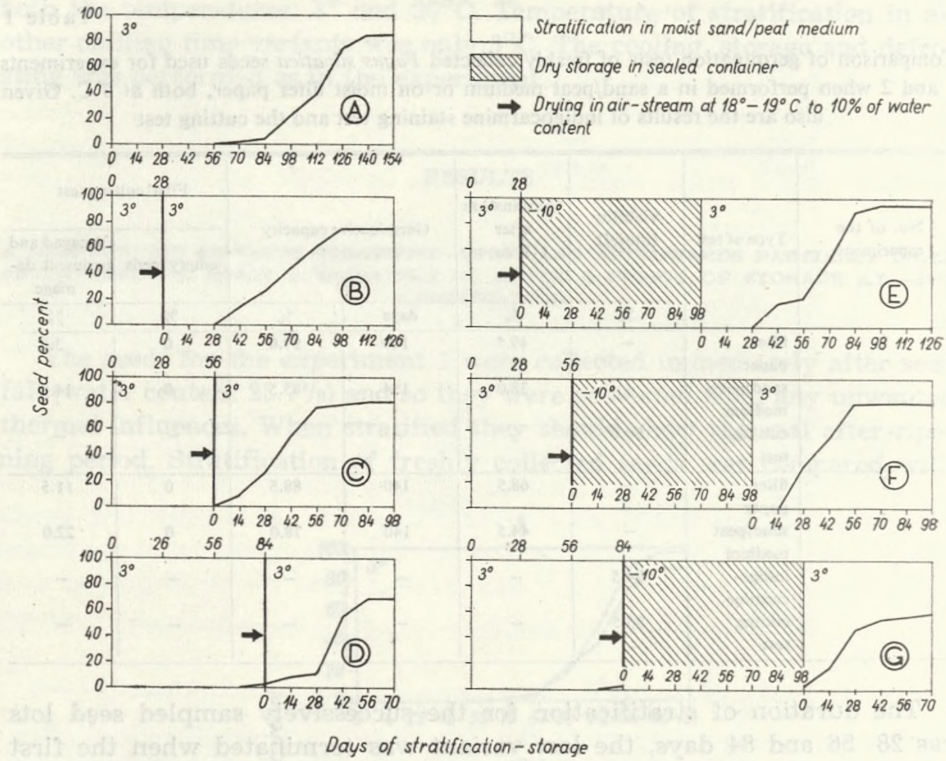

Fig. 4. Experiment 1. Germination during stratification at 3°C of *Fagus silvatica* seeds when freshly collected, or when stratified for 28, 56 and 84 days and afterwards dried to 10% of water content (fresh weight basis) and again stratified immediately (B-D) or after storage at —10°C lasting 98 days (E-G)

Table 2

Experiment 1. Results of stratification at 3°C of *Fagus silvatica* seeds and of final cutting tests of non-germinated seeds. The seeds were stratified after collection at 3°C and afterwards they were dried to 10 % of water content (fresh weight basis) and stratified again immediately or after a subsequent storage at −10°C lasting 14 weeks

	Duration of stratification at 3°C preceding drying	Stratification at 3°C after drying			Final cutting test	
		germination after 42 days	germinative capacity		empty seeds	decayed seeds
	days	%	days	%	%	%
Seeds	28	15.2	98	75.7	0	24.3
stratified	56	55.6	84	80.8	0	19.2
after drying	84	54.5	56	69.7	0	30.3
Seeds stratified	28	18.2	98	94.4	0	6.6
after drying followed by storage	56	54.5	70	81.9	0	18.1
at −10°C	84	54.4	70	58.5	0	41.5

instructive is the last variant with seeds dried when the first radicles began to appear (after 84 days of stratification) and then stored at −10°C. After termination of storage and defrosting they began immediately to continue their germination during the new cold stratification at 3°C. The question arises how would such seeds react when brought after storage into warm conditions e.g. at 20°C. In the cold stratification conditions the after-ripening process was simply continued and the low temperature of storage contributed in some degree to its better progress.

B. GERMINATION OF SEEDS CHILLED AT 3°C WITHOUT ANY MEDIUM AND AFTERWARDS STRATIFIED IMMEDIATELY AT THE SAME TEMPERATURE OR PARTIALLY DRIED AND STRATIFIED AFTER STORAGE AT —10°C (EXPERIMENT 2)

In experiment 2 beechnuts were collected over a two-weeks period, always on the day they fell off the trees. The initial, water content of these seeds was 28.3%. The seed viability was tested as in experiment 1. The germination tests of freshly collected seeds were performed by stratification, and by spreading on moist filter paper, both at 3°C (Fig. 3). The seeds germinated between the 10th and the 20th week, but on filter paper they germinated more energetically and to a higher percent (88.5% in contrast to 78% in the stratification medium). These results demonstrate that beech trees growing in Kórnik represent a lowland ekotype with seeds having a long lasting after-ripening time.

The main bulk of seeds was kept carefully at their initial water content of 28.3% without any medium in boxes with perforated lids at 3°C. Every three weeks till the 18th week of chilling samples of seeds were taken for a stratification at 3°C or they were dried to 10% w.c. at 18° - - 19°C for 48 hours and were stored at −10°C and afterwards also stratified like seeds from experiment 1. The results of the experiment 2 are shown in Table 3 and Fig. 5.

As concerns the germinative capacity of seeds from experimental variants without drying of the seeds there is no difference depending on the duration of the chilling time. It was always in the range 70 - 80%. In the series of variants with drying and storage the germinative capacity of seeds stratified at 3°C varied more, from 68.5 to 86%.

However a striking difference became visible in the behaviour of the seeds during the chilling time and in the course of their germination. The chilled seeds having a water content lower than the stratified seeds from experiment 1 (28.3% in contrast to 36.6%) did not germinate during chilling even when treated for the longest time that is for 126 days. Up till the 105th day the longer lasted the chilling the more energetic and shorter was the germination period during the subsequent stratification applied imediately after chilling or after chilling followed by drying and storage. Nearly all seeds chilled for 84 or 105 days germinated in 28 days

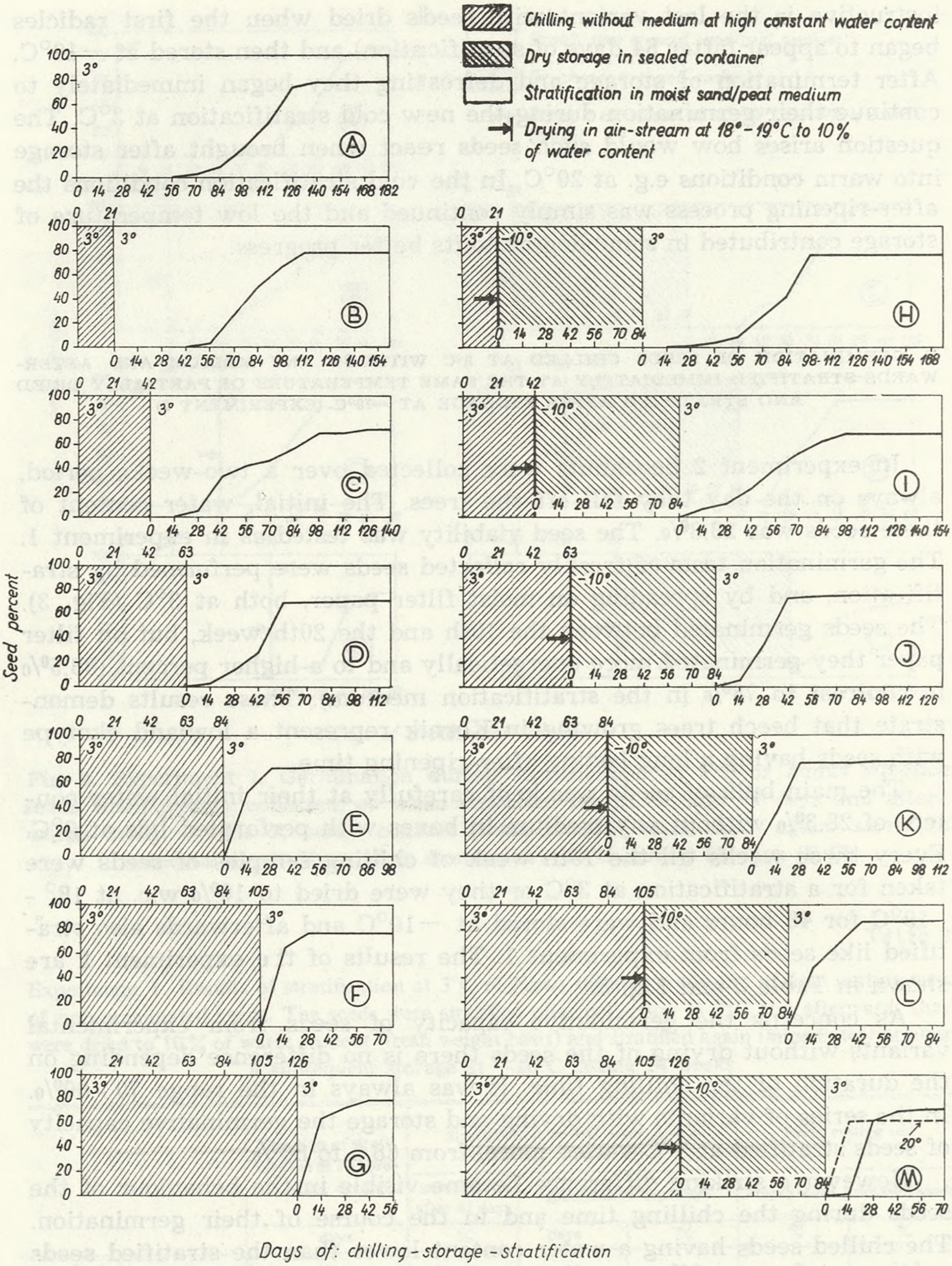

Fig. 5. Experiment 2. Germination during stratification at 3°C of *Fagus silvatica* seeds when freshly collected (A) or when chilled at 3°C at a constant water content of 28.3% (fresh weight basis) for 21, 42, 63, 84, 105 or 126 days without any medium, and afterwards stratified immediately or (B-G) after drying to 10% of water content followed by storage at —10°C lasting 84 days (H-M). In one case (M) a stratification temperature of 20°C was also employed

Table 3

Experiment 2. Results of stratification at 3°C of *Fagus silvatica* seeds and of final cutting tests of non-germinated seeds. The seeds were chilled after collection at 3°C without any medium and afterwards stratified immediately or after drying to 10% of water content (fresh weight basis) and a subsequent storage at −10°C lasting 12 weeks

	Duration of chilling at 3° C	Stratification at 3°C			Final cutting test	
		germination after 14 days	germinative capacity		empty seeds	decayed seeds
	days	%	days	%	%	%
Seeds stratfied immediately after chilling	0	0	140	78.0	0	22.0
	21	0	112	78.0	0	22.0
	42	0	126	72.0	0	28.0
	63	2.5	98	71.0	0	29.0
	84	52.5	56	74.0	0	26.0
	105	64.5	28	77.5	0	22.5
	126	64.0	42	79.0	0	21.0
Seeds stratified after chilling followed by drying and storage at −10°C	21	0	98	76.0	0	24.0
	42	6.5	98	68.5	0	31.5
	63	4.5	70	75.5	0	24.5
	84	36.0	70	78.0	0	22.0
	105	48.0	42	86.0	0	14.0
	126	1.0	70	71.0	0	29.0
		61.0*	28*	62.0*	0*	38.0*

* Data for seed lot tested at 20°C.

of the subsequent cool stratification and this germination began directly after the onset of the stratification. These seeds were prepared for germination already during the chilling and this ability was preserved despite the partial drying to 10% w.c. at 18° - 19°C and storage at −10°C. Seeds chilled for 126 days had a lower germination energy and capacity. It is remarkable that these latter seeds germinated nearly as good but faster at 20°C than at 3°C. Unfortunately of the scarceness of seed material seeds from the other chilling time variants were not tested at the higher of these two temperatures.

We see that beech seeds can be after-ripened at a temperature just above 0°C without any medium when their water content is sufficiently high for after-ripening but too low for germination. Ich such conditions (here 3°C, 28.3% w.c., aeration) the seeds were prepared for germination but this was prevented by the circumstances described. The fast partial drying (from 28.3% to 10% w.c.) did not change the attained level of after-ripening, so that more and more seeds could germinate immediately after an increase of their water content during stratification at 3°C. Their physiological state was not changed by a partial drying and 84 days of storage at −10°C.

In this experiment it was shown that it is possible to after-ripen beech seeds by chilling without any medium and that there does not exist any danger of an untimely germination. It is also possible to stop the after-ripening process by rapid partial drying at temperatures not exceeding 20°C. The reached level of this readiness for germination can be preserved by storage in sealed containers at −10°C. The greatest advantage of such a treatment is the energetic and very early germination at low temperatures (here 3°C) after termination of the storage period.

DISCUSSION

We have shown that it is possible to store after-ripened beech seeds, and to preserve their germination readiness by drying and cold storage and even to shorten substantially the germination time after drying whether followed or not by a storage.

An analysis of data on the origin of beech seed material used for storage experiments by different authors shows that they used mostly seeds already partially after-ripened on the ground and also later, during the so called "drying" which should prepare them for storage. This drying happens always in the cool time following beech seed collection that is in the late Autumn or early winter in cellars, barns, sheds or attics. In our experiments (Suszka, 1966, 1974) the used seeds were collected immediately after seed fall and thus protected from any influence of the low uncontrolled temperature when still highly hydrated. The different stages of after-ripening of seeds seem to be the reason for the confusing data concerning duration of the necessary stratification. We have shown here (Figs. 4 and 5) that the stratification time after drying is strongly dependent on the progress in the after-ripening process preceding this drying. We have shown how different it can be even in seeds from the same seed lot only when the time of stratification or chilling without medium before drying was differenciated. In an earlier paper (Suszka, 1974) we demonstrated that seeds from Polish mountain provenances (Carpathians elev. 900 m) needed a much shorter stratification time for germination at the low temperature than the lowland provenance, but the germination time did not differ seriously when storage was prolonged and the after-ripening temperature was 1° or 3°C. It seems that the mountain provenance coming from regions with much shorter periods between seed fall and the snow fall is hereditarily adapted in the reaction of their seeds to mountainous thermal and time conditions.

It should be pointed out that the temperature employed in our work for drying of beechnuts is very close to that found by Vlase (1969) as the optimal temperature for rapid drying (18° - 19°C in our work, 15°C used by Vlase).

Nurserymen are interested in energetical, high-percent germination over a short time as early as possible after the sowings in the ground, when there is no danger of late frosts that means when the soil and air temperatures are alrealy high. Is seems that the results presented in this paper elucidate facts observed by some authors, who found that after long-lasting "drying" of seeds in cool conditions the seeds needed only a short stratification (R o h m e d e r, 1951; S c h ö n b o r m, 1964). Very interesting results were obtained by M a c h a n í č e k (1973) who did not succeed in drying big amounts of beech seed (12.5 tons) in a cool brewery cellar, so that after a longer period of such treatment (in reality after-ripening) he had to dry them quickly in a hop-kiln at 10° - 25°C for 8 hours to prepare them for storage at −20°C. When these seeds after storage at this temperature over one or two winters were sown in the nursery in cool conditions (but protected from freezing in the soil) a successful germination was obtained. When sown in nurseries in late Autumn, so that they were brought into already frozen ground or covered after sowings by snow, these seeds did not germinate the following Spring. It is clear that in this last case they did not find the necessary conditions needed for completion of their after-ripening.

We hope that it will be possible to after-ripen beech seeds on a large scale by chilling without any medium in cool controlled thermal conditions, later to dry them rapidly to 10% of water content using special drying facilities equipped with ventilators (as already proposed by B u s z e w i c z (1962a) or V l a s e (1968), and to store them afterwards in sealed containers at temperatures below freezing point like the not after-ripened seeds (S u s z k a, 1966, 1974). The ability to germinate immediately after the onset of cool stratification following their storage would make possible to pregerminate these seeds after storage in moist and cool conditions and to sow them when the radicles are still very short and the outside weather still cool. This should assure an energetical mass seedling emergence in the nursery. The problem still to study is to see if the 12 - 14 weeks of storage employed in this work could be prolonged to some years without any harm to the viability and germinative energy and capacity of the seeds.

SUMMARY

1. Germination tests of beech seed on moist filter paper at 3°C result in better and more energetic germination than the stratification tests in moist sand/peat medium at the same temperature.

2. Freshly collected beech seed can be after-ripened not only by a cold stratification in the sand/peat medium at temperatures from the range 1° - 5°C but also by chilling without any medium at 3°C (the only temperature studied) in aerated containers when the high initial water content (here 28.3%) is maintained by sprinkling and mixing. This moisture content should be preserved unchanged over the whole chilling time with the aid of weighings repeated in regular time intervals using always the same seed numbers collected at random.

3. Chilled or stratified seeds can be dried from 36 - 37% in the case of stratified seeds and from 28% for the chilled ones to 10% of their water content (on fresh weight basis) at 18° - 19°C in an air stream from a ventilation fan in about 48 hours. The viability and germinability of the partially dried seeds is not lowered by this treatment.

4. Beech seeds dried after stratification or after chilling without a medium to 10% of water content can be stored in sealed containers at −10°C without any harm to their viability and germinability. Their germination time decreases substantially with the prolongation of the after-ripening time before drying and the subsequent storage.

5. The drying of stratified seeds should be performed at the latest when the first radicles begin to appear. In the case of seeds of the studied lowland beech provenance the best time for drying was after 56 days of stratification that is 28 days before the onset of germination. Chilling without any medium was extended in this study for 126 days without any signs of germination and this after-ripening treatment gave the best results when the seeds were chilled for 84 - 105 days and afterwards stratified immediately or after partial drying followed by storage at −10°C.

6. For cooling of seeds before storage at −10°C and their defrosting after storage they were placed at 1°C for one day.

7. In our study the storage at −10°C of earlier stratified seeds lasted 98 days, and that of seeds chilled without medium 84 days; it seems possible that this storage time could be prolonged as in the case of non-after-ripened seeds for much longer periods.

8. From the practical point of view the best procedure would be to collect lowland beechnuts immediately after seed fall, to bring them if necessary to the 28% of water content, to store them at this unchanged hydration level in containers with perforated lids in refrigeration chambers maintained at 3°C, to dry them afterwards rapidly at 15° - 20°C (after 84 - 105 days of chilling) down to 10% of water content and to store them at −10°C in sealed containers, after cooling at a low near 0°C temperature for one day. After completion of the storage period the seeds should be defrosted at the near 0°C temperature and sown in the ground directly when the soil temperature is still low or after a short stratification. This should result in a very energetical mass germination.

Institute of Dendrology
Kórnik nr. Poznań

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BOLESŁAW SUSZKA

Przechowywanie w obniżonej temperaturze nasion buka zwyczajnego (Fagus silvatica L.) przysposobionych uprzednio do kiełkowania przez chłodną stratyfikację lub składowanie w chłodzie

Streszczenie

W Instytucie Dendrologii PAN w Kórniku przeprowadzono w sezonie 1973 - 74 badania nad przechowywaniem nasion buka przysposobionych bezpośrednio po zbiorze do kiełkowania przez chłodną stratyfikację lub przechowywanie w chłodzie bez jakiegokolwiek podłoża.

Wyniki przeprowadzonych badań są następujące:

1. Nasiona buka (w całych orzeszkach) kiełkują w wyższym procencie i bardziej energicznie na bibule w 3°C niż podczas stratyfikacji w piasku z torfem w tej samej temperaturze.

2. Spoczynek nasion buka ustępuje nie tylko podczas stratyfikacji w wilgotnym podłożu (piasek z torfem) w temperaturach zakresu 1° - 5°C, lecz również podczas składowania samych orzeszków bez jakiegokolwiek podłoża w 3°C (jedyna temperatura zastosowana w badaniach) w pojemnikach umożliwiających wymianę gazową przy zachowaniu bez zmian początkowego poziomu zawartości wody (tu 28,3% w świeżej masie). Tę zawartość wody można utrzymać przeprowadzając w regularnych odstępach czasu ważenie losowo pobranych próbek o stale tej samej liczebności orzeszków, a w razie potrzeby przez zraszanie wodą i staranne mieszanie. Ma to na celu utrzymanie ciężaru orzeszków na niezmienionym poziomie.

3. Orzeszki buka podsuszano z 36 - 37% w przypadku stratyfikacji i z 28% w przypadku chłodzenia bez podłoża do 10% zawartości wody (w świeżej masie) w prądzie powietrza o temperaturze 18° - 19°C w ciągu około 48 godzin. Sposób ten nie obniża ani żywotności, ani zdolności kiełkowania nasion.

4. Orzeszki buka podsuszone po stratyfikacji lub po chłodnym składowaniu do

10% zawartości wody można przechowywać w szczelnie zamkniętych pojemnikach w —10°C, bez szkody dla ich żywotności i zdolności kiełkowania. W miarę przedłużania stratyfikacji lub składowania w chłodzie nie podsuszonych nasion okres ich kiełkowania ulega wydatnemu skróceniu.

5. Kiełkujących nasion buka nie należy podsuszać. W przypadku użytych przez nas nasion (proweniencja nizinna) najwcześniejsze i najbardziej intensywne kiełkowanie uzyskano, gdy podsuszanie przeprowadzono po 8 tygodniach stratyfikacji, tzn. na 4 tygodnie przed pojawieniem się pierwszych kiełków. W przypadku orzeszków nie stratyfikowanych po zbiorze, lecz składowanych w 3°C bez jakiegokolwiek podłoża nie obserwowano żadnych oznak kiełkowania aż do 126 dnia, to jest aż do końca okresu składowania. Ten sposób likwidacji spoczynku dał najlepsze rezultaty, gdy składowanie w chłodzie trwało 84 - 105 dni. Tak przysposobione nasiona kiełkowały intensywnie podczas stratyfikacji rozpoczynanej zarówno natychmiast po zakończeniu składowania, jak i podczas stratyfikacji przeprowadzonej po podsuszeniu i przechowywaniu orzeszków w —10°C.

6. Schładzanie nasion przed przechowywaniem w —10°C i ich odmrażanie przeprowadzano w temperaturze 1°C przez 1 dobę.

7. W badaniach naszych orzeszki stratyfikowane przechowywano w —10°C przez 98 dni, orzeszki składowane w chłodzie bez podłoża przechowywano przez 84 dni. Wydaje się, że okres przechowywania można będzie znacznie przedłużyć.

8. Z praktycznego punktu widzenia najbardziej celowy wydaje się następujący sposób postępowania z nasionami buka nizinnego. Zbiór orzeszków w miarę ich opadania z drzew, oddzielenie nasion pustych i uszkodzonych, jeśli to konieczne — doprowadzenie poziomu uwodnienia orzeszków do 28% (w świeżej masie), składowanie ich przy tej zawartości wody w pojemnikach z perforowanymi wiekami w chłodni przy 3°C przez 84 - 105 dni, szybkie podsuszenie prądem powietrza o temperaturze 15° - 20°C do 10% zawartości wody, umieszczenie orzeszków w szczelnych pojemnikach, a następnie (po schłodzeniu w około 0°C przez 1 dobę) w chłodni w temperaturze —10°C. Po zakończeniu przechowywania i rozmrożeniu orzeszków (nieco powyżej 0°C przez 1 dobę) można je wysiewać wiosną wprost do gruntu lub po krótkotrwałej stratyfikacji chłodnej. W efekcie należy się spodziewać masowych wschodów.

БОЛЕСЛАВ СУШКА

Хранение при пониженной температуре семян Fagus silvatica L. подготовленных к прорастанию холодной стратификацией или содержанием в холоде без субстрата

Резюме

В Институте дендрологии ПАН в Курнике в сезоне 1973 - 1974 г. проводилось изучение хранения семян бука, подготовленных сразу после сбора к прорастанию методом холодной стратификации или содержанием их в холоде без какого-либо субстрата.

Результаты проведенных исследований таковы:

1. Семена бука (в целых орешках) прорастают в большем проценте и более энергично на промокательной бумаге при 3°С, чем во время стратификации в песке с торфом при той же температуре.

2. Покой семян бука прерывается не только во время стратификации во влажном субстрате (песок с торфом) при температуре в пределах 1 - 5°С, но также при складировании орешков без какого-либо субстрата при 3°С (только при этой температуре

ставились опыты), в контейнерах, делающих возможным газообмен без изменения исходного уровня содержания воды (в данном случае 28,3% в сырой массе), Это содержание воды можно удерживат, проводя через определенные промежутки времени взвешивание случайно выбранных проб орешков (в том же самом числе) и в случае необходимости увлажнения их и перемешивания с целью сохранения веса орешков на неизменном уровне.

3. Орешки бука подсушиваются в токе воздуха (температура 18—19°C) в течение около 48 часов. Содержание воды в них падает до 10% (сырой массы) с 36 - 39% в случае стратификации и с 28% в случае складирования при низкой температуре без субстрата. Этот метод не снижает ни жизненности семян, ни их способности к прорастанию.

4. Орешки бука, подсушенные после стратификации или после складирования при низкой температуре до 10% содержания воды, можно хранить в герметически замкнутых контейнерах при −10°C без вреда для их жизненности и способности к прорастанию. По мере продления стратификации или холодного складирования неподсушенных семян их способность к прорастанию подвергается существенному сокращению.

5. Стратифицированные орешки можно подсушивать самое позднее после появления первых ростков. В случае исследованных нами семян низинного происхождения наиболее благоприятным было подсушивание их после восьми недель стратификации, т.е. за четыре недели до появления первых проростков. Хранение в холоде без субстрата продолжалось в наших опытах до 18 недель без каких-либо признаков прорастания. Этот метод ликвидации покоя семян давал наилучшие результаты тогда, когда охлаждение продолжалось 12 - 15 недель. Так подготовленные семена можно было стратифицировать с целью проращивания непосредственно после окончания складирования или после подсушивания хранившихся орешков и последующего содержания их при −10°C.

6. Охлаждение семян перед помещением их в температуру −10°C и их размораживание осуществлялось в течение суток при 1°C.

7. В наших исследованиях стратифицированные орешки содержались при −10°C в течение 14 недель. Орешки же, хранившиеся в холоде без субстрата, содержались при −10°C 12 недель. Представляется, что указанные сроки можно будет значительно удлинить подобно тому, как это имеет место в случае многолетнего хранения подсушенных покоящихся семян.

8. С практической точки зрения наиболее целесообразным представляется следующий способ действия: сбор орешков по мере их опадания с деревьев; отделение пустых и поврежденных орешков; доведение в случае необходимости уровня содержания воды в орешках до 28% (в сырой массе); складирование их при этом увлажнении в контейнеры с перфорированными крышками на 12 - 15 недель в холодильники с температурой 3°C; быстрое подсушивание их воздушным током с температурой 15° - 20°C до уменьшения содержания воды до 10%; помещение орешков в температуру −10°C в герметически закрытых контейнерах и после предварительного суточного охлаждения при 1°C. После окончания хранения их в этих условиях орешки в течение суток размораживаются при температуре около 0°C. Вслед за этим семена можно высевать или сразу после непродолжительной стратуфикации самой ранней весной, насколько это возможно в условиях данной школки. В результате следует ожидать массовых всходов.