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Conditions for the after-ripening of cherry plum (*Prunus cerasifera* var. *divaricata* Bailey) seeds. II. The withholding of seed germination*

Abstract

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The process of after-ripening and seed germination has been arrested by partial drying at 16°C or by lowering the temperature to −1° or −3°C. In both cases the withholding of germination was tried after 4, 8 and 11 - 12 weeks (the latter being the time of appearance of the first germinating seeds) of the last cold phase of stratification (3°C).

The smallest losses in the germination capacity of partially dried seeds have been observed (after 4 - 8 weeks of storage) when the partial drying (to 13 - 16% of moisture content) has been performed after 2/3 of the 3°C stratification time needed for the first germinating seeds to appear has passed (i.e. after 8 weeks). A more successful technique for the withholding of seed germination depends on the lowering of temperature to −3°C which can be performed both after 8 and 11 - 12 weeks. The seed dormancy will be overcome the sooner (at stratification conditions or in the ground after sowing the seeds) the more advanced was the after-ripening process prior to partial drying or lowering of the temperature below 0°C.

Additional key words: dormancy, stratification, drying, freezing.

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INTRODUCTION

Withholding the process of seed germination, particularily of seeds which germinate early during stratification, permits the saving of a major proportion of them from being irreversibly lost when unsatisfactory weather conditions do not permit their sowing. In practice various me-

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thods are known of delaying the after-ripening process in seeds. These include the use of substances which are osmotically active such as mannitol or polyethylene glycol (PEG), the dehydration of seeds by partial drying, the lowering of temperature below 0°C or the induction in seeds of secondary dormancy. This latter method of withholding seeds from germination can be used when the primary dormancy has not been fully overcome and it creates the need for a *de novo* stratification of the seeds for the full length of time (Suszka 1967).

The use of solutions of osmotically active substances allows the seeds to pick up only as much water as is needed for the after-ripening process to continue, but the amount is insufficient for the growth of the radicle (Heydecker 1973/74, 1975 a and b, Heydecker et al. 1975, Simak 1976, Muller and Bonnet-Masimbert 1983).

The dehydration of incompletely stratified seeds by partial drying is used with success for many species of trees and shrubs. It is important however that the partial drying takes place in a relatively short time and at a not too high temperature. A review of literature concerning this topic has been made by Grześkowiak and Suszka (1983) who worked on the storage of partially dried seeds of mazzard cherry after incomplete stratification.

The most commonly used method of withholding seeds from premature germination during stratification is to lower the temperature. In practice this usually depends on the transfer of seeds to a cold room or else placing them in snow where the temperature is maintained within the limit 0°C to −1°C (Tyszkiewicz 1949, Terpiński 1971, Bärtels 1982). Besides inhibiting the growth of radicles at this temperature some authors have observed a positive effect of the −1°C temperature on frozen imbibed seeds manifested in a substantial increase in the germination capacity of the seeds after their transfer to conditions favouring germination (Ven'jaminov and Dolmatova 1959, Kamiński 1983).

It was the purpose of the present study conducted on the seeds of cherry plum to evaluate the response of the seeds during stratification to partial drying or freezing at various stages of after-ripening.

MATERIALS AND METHODS

For studies on the withholding of the germination process use was made of three commercial lots of cherry plum (*Prunus cerasifera* var. *divaricata* Bailey) seeds bought in the Seed Center for Horticulture and Nurseries (CNOS) in Poznań. The seeds were from the 1980 collection season. After 6 months storage (4 months in the stores of CNOS and 2 months in closed containers at −1°C) immediately before starting strati-

Table 1

Water content and viability of seeds used in the study

Seed lot No	Water content		Viability %
	Seed %	Stones %	
508	7.2	12.5	97.0
509	6.9	12.2	100.0
510	7.8	12.9	100.0

fication the water content was determined (by drying for 24 h at 105°C) and the seed viability tested (in a water solution of indigocarmine 1 : 2000, 2 h, Tab. 1).

The stones were stratified in a moist mixture of sand and peat (1 : 1 v/v) in three thermal systems: 3°, 20°/3° or 20°/3°/25°/3° with two week periods of the warm temperature (Fig. 1). In the last cold phase of the thermal systems, that is after 4 and 8 weeks of stratification in 3°C and in the period when first germinating seeds appear, the temperature was lowered to −1°C or to −3°C for a period of 4 to 8 weeks after which stratification was further continued at 3°C until no more seeds were germinating (Fig. 1).

For the experiment on the withholding of cherry plum seed germination by partial drying use was made of only one commericial seed lot

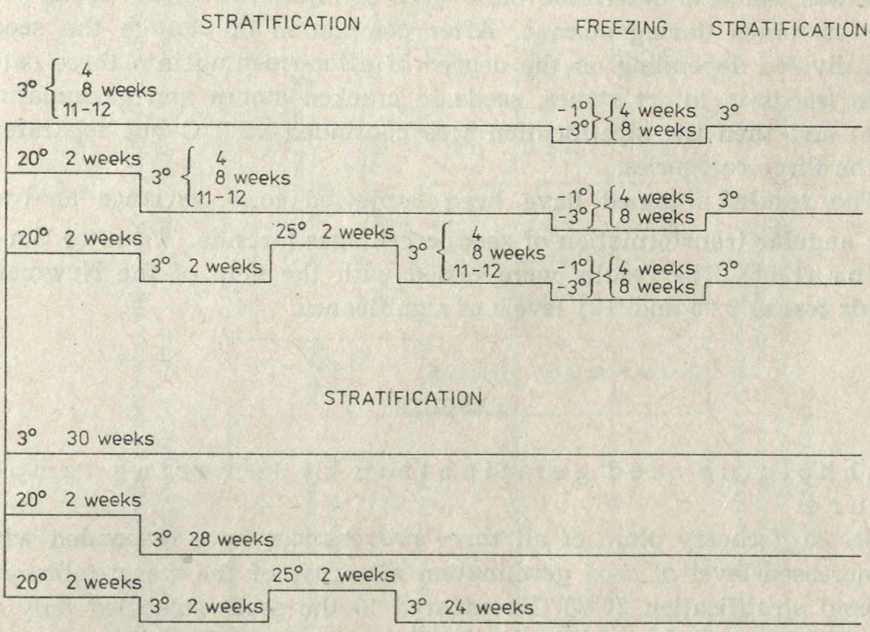


Fig. 1. Pattern of the experiment on the withholding of cherry plum seeds germination by lowering stratification temperature below 0°C

from the 1980 collection. The stones were bought in CNOS Poznań. The stratification of seeds was started after 17 months of storage (6 months in the CNOS store and then in a sealed container at a temperature of −1°C). After storage the water content of seeds was 7.4% (whole stones 12.9%), and their viability was 98.5%.

The warm-followed-by-cold stratification 20°/3°C (two weeks in 20°C and then in 3°C) was employed in 4 replicates with 50 seeds each (Fig. 2). After 4, 8 and 12 weeks of the cold phase in 3°C the stratification was interrupted and the seeds were partially dried in an air current at a temperature of 16°C (±0.7°C) for 1 or 7 days, after which the seeds were stored in seald bottles at −1°C for 4 or 8 weeks (Fig. 2). After partial drying and the completion of storage at −1°C the viability of seeds was tested to determine the degree of injury which the seeds possibly sustained during storage. After completion of storage the seeds were divided depending on the degree of after-ripening into three categories (seeds in intact stones, seeds in cracked stones and germinating seeds) and then the stratification was continued at 3°C but separately for the three categories.

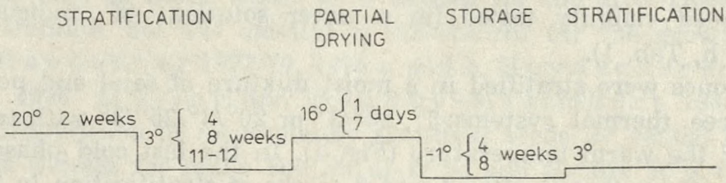


Fig. 2. Pattern of the experiment on the withholding cherry plum seed germination by partial drying of seeds

The results obtained have been subjected to a variance analysis after angular transformation of seed percentages (arcsine$\sqrt{\%}$) after Snedecor (1956). The results were tested with the help of the Newman-Keuls test at 0.05 and 0.01 levels of significance.

RESULTS

Withholding seed germination by lowering temperature

Seeds of cherry plum of all three provenances have responded with an increased level of seed germination after use of the warm-followed-by-cold stratification 20°/3°C compared to the seeds stratified only at 3°C. The use of the additional thermal stimulus (25°C for 2 weeks) induced a secondary dormancy after the prior warm-followed-by-cold (2+2 weeks) stratification, and the further stratification at 3°C resulted

Table 2

Germination capacity of three seed lots of cherry plum stratified in various thermal conditions. The after-ripening process was interrupted in the final stage of stratification (after 4, 8 and 11 - 12 weeks at 3°C) by lowering temperature to −1° or −3°C for a period of 4 to 8 weeks, after which the stratification at 3°C was continued

Thermal conditions of stratification	Freezing time	Seed lot no. 508					509					510				
		Freezing duration					Freezing duration					Freezing duration				
		0 weeks	4 weeks		8 weeks		0 weeks	4 weeks		8 weeks		0 weeks	4 weeks		8 weeks	
			freezing temp.		freezing temp.			freezing temp.		freezing temp.			freezing temp.		freezing temp.	
			−1°C	−3°C	−1°C	−3°C		−1°C	−3°C	−1°C	−3°C		−1°C	−3°C	−1°C	−3°C
3°C	A		6.0	4.7	8.7	1.3		14.0	6.0	10.7	4.0		15.3	15.3	12.7	8.7
	B		17.3	13.3	12.0	18.7		18.7	30.7	20.0	24.7		6.0	16.7	6.7	13.3
	C		9.3	17.3	10.7	18.0		18.0	30.0	32.7	22.7		3.3	15.3	5.3	11.3
	D	17.3					33.3					10.7				
20°/3°C	A		33.3	33.3	28.0	46.7		49.3	61.3	40.7	61.3		52.0	54.7	51.3	46.0
	B		43.3	48.7	44.0	47.3		57.3	69.3	68.7	54.7		66.7	60.0	65.3	67.3
	C		53.3	52.7	35.3	51.3		66.7	76.3	69.3	67.3		73.3	67.3	67.3	66.7
	D	63.3					76.0					79.3				
20°/3°/25°/3°C	A		49.3	51.3	38.7	36.7		64.7	63.3	68.0	66.7		63.3	85.3	68.7	70.7
	B		70.0	78.7	74.7	66.0		74.7	68.7	74.7	62.7		84.0	82.0	79.3	77.3
	C		80.7	66.7	62.0	81.3		69.3	63.3	74.0	65.3		85.3	75.3	67.3	81.3
	D	78.7					90.0					94.0				

A – freezing after 4 weeks of stratification at 3°C
B – freezing after 8 weeks of stratification at 3°C
C – freezing when germination of seeds starts (after 11–12 weeks)
D – control without freezing

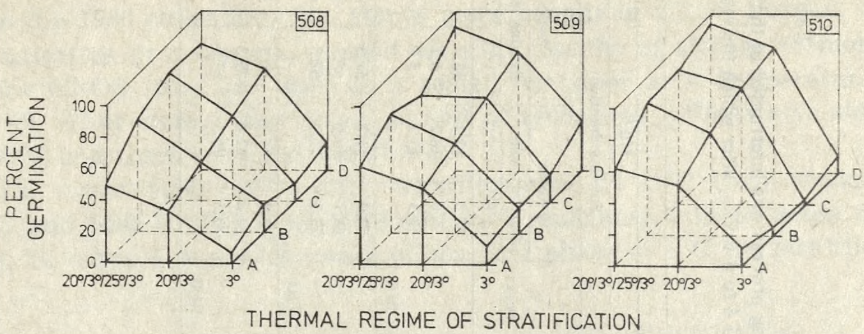


Fig. 3. Comparison of the germination capacity of three lots of cherry plum seeds (508, 509 and 510) which have been subjected to stratification in three different thermal regimes. After 4, 8 and 11 - 12 weeks (the onset of seed germination) of stratification in the last cold phase at 3°C the seeds were frozen at −1°C or −3°C (mean values over the two temperatures) for 4 or 8 weeks. A — freezing after 4 weeks of stratification at 3°C, B — freezing after 8 weeks of stratification at 3°C, C — freezing when first seeds started to germinate (after 11 - 12 weeks, D — control without freezing

in an even greater proportion of seeds germinating than after a warm--followed-by-cold stratification only (Tab. 2, Fig. 3).

The lowering of temperature to −1°C or to −3°C during dormancy breaking for seeds of cherry plum has only withheld the after-ripening process without inducing dormancy in the seeds. A further stratification

Table 3

Influence of a temporary lowering of temperature below 0°C during the after-ripening of cherry plum seeds on their germination capacity. Results of variance analysis. In the table nonsignificant interactions are left out

Source of variation	Degrees of freedom	SS	MS	$F_{emp.}$
Experimental variables	107			
Stratification systems (S)	2	77695.45	3884.72	175.94**
Freezing temperatures (T)	1	167.90	167.90	7.60**
Freezing duration (D)	1	145.34	145.34	6.58*
Provenance (P)	2	3206.91	1603.45	72.62**
Stage of after-ripening (A)	2	4240.75	2120.38	96.03**
S×P	4	2349.22	587.30	26.60**
P×A	4	821.37	205.34	9.30**
S×T×P	4	404.17	101.04	4.58**
S×T×A	4	983.65	245.91	11.14**
S×P×A	8	1774.50	221.82	10.05**
T×D×P	2	189.27	94.64	4.29**
S×T×D×A	4	510.05	127.51	5.77**
S×T×P×A	8	1018.98	127.37	5.77**
T×D×P×A	4	484.55	121.14	5.49**
Residual	216	4770.36	22.08	
Total	323	100284.86	310.48	

* – significant at a 0.05 level
** – significant at a 0.01 level

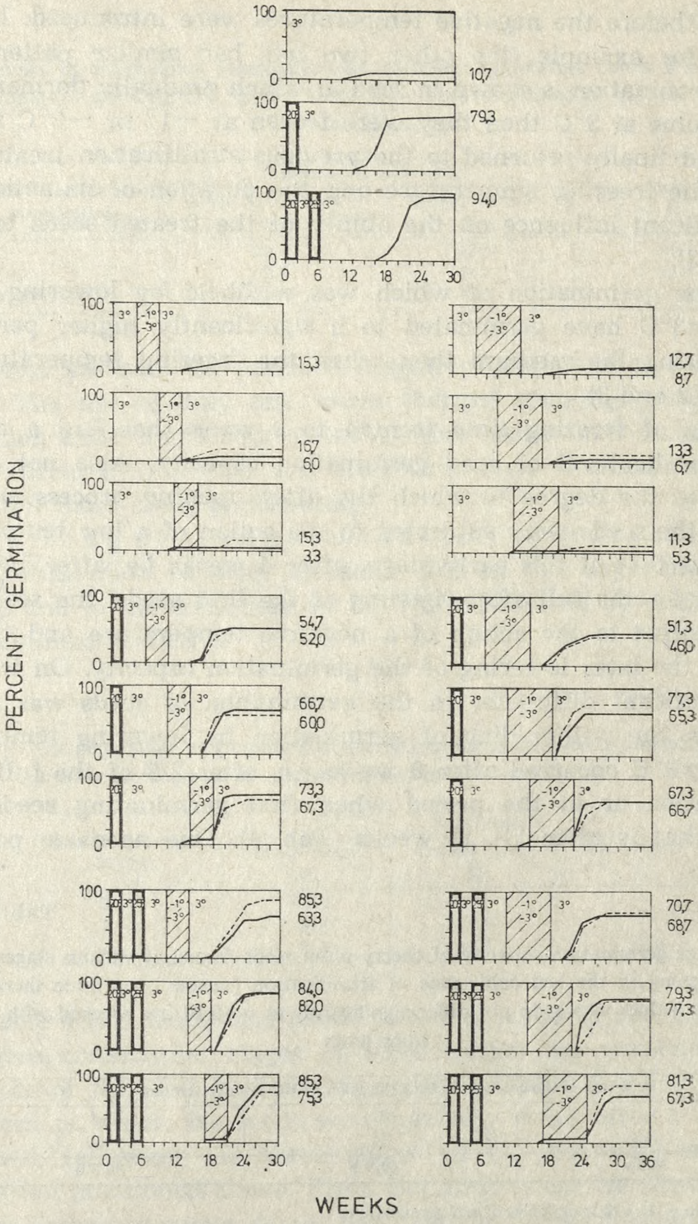


Fig. 4. The course and germination capacity of cherry plum seeds (lot 510) in which the process of after-ripening has been interrupted by lowering temperature to -1° or -3°C for 4 or 8 weeks (hatched area), after which the seeds were again stratified at 3°C. Continuous lines show the course of germination of seeds after freezing at -1°C and the broken lines after freezing at -3°C

at a temperature of 3°C allowed the process to be completed and the seeds to start germination. The onset of seed germination after defreezing occured the earlier the more advanced was the process of seed germination before the negative temperatures were introduced. In fig. 4 in lot 510 for example (the other two lots had similar patterns) the course of germination is shown in seed in which gradually dormancy was being overcome at 3°C then they were frozen at −1° or −3°C for 4 or 8 weeks, and finally returned to the previous stratification treatment at 3°C. Both the freezing temperature and the duration of its action have had a significant influence on the ability of the treated seeds to germinate (Tab. 3).

Seeds, the germination of which was withheld by lowering temperature to −3°C have germinated to a significantly higher percentage after defreezing the medium then when the freezing temperature was −1°C (Tab. 2 and 3).

Extension of freezing time from 4 to 8 weeks has had a negative influence on the level of seed germination capacity. Also not without influence was the degree to which the after-ripening process advanced at the time the seeds were subjected to the action of a low temperature. It turned out that at this early stage, after 4 weeks i.e. after 1/3 of the time needed for the full after-ripening of the first seeds, the seeds were already sensitive to the action of a negative temperature and this was reflected in the later lowering of the germination capacity. On the other hand a significant difference in the germination of seeds was not observed when the withholding of germination by lowering temperature to −1° or −3°C occurred after 8 weeks i.e. after 2/3 of the full period of stratification or in the period when first germinating seeds begin to appear, that is after 11 - 12 weeks (Tab. 4). One needs to point out

Table 4

Percentage germination capacity of cherry plum seeds frozen at various stages of after-ripening in the last cold stage of stratification (means over three thermal systems). Values which do not differ significantly at $p=0.01$ are marked with the same letter

Weeks of the cold state of stratification at 3°C prior to freezing		
4 %	8 %	Go* %
38.5 a	49.9 b	50.3 b

* Go – 11 - 12 weeks/onset of seed germination

however that in the initial stage of germination the lowering of temperature below 0°C contributed to the appearance of frost injuries in all radicles of already germinated seeds. After defrosting a substantial proportion of these seeds underwent decay and only few, less injured ones, formed adventitious roots and grew into seedlings.

Analysing the results presented in Table 5 one can suggest that the warm thermal stimuli (20° and 25°C) lower the level of sensivity of

Table 5

Influence of withholding germination by lowering temperature below 0°C on the germination capacity (in %) of cherry plum seeds stratified in various thermal conditions

Thermal conditions of stratification	Germination capacity %		% of control $\frac{B}{A} \cdot 100$ %
	A = without freezing %	B = with freezing %	
3°C	20.4	13.6	66.7
20°/3°C	72.8	54.7	75.1
20°/3°/25°/3°C	87.7	68.7	78.8

cherry plum seeds to the action of negative temperatures during stratification. The use of only one warm thermal stimulus resulted in the germination after defreezing of 8.4% more seeds than when the seeds were stratified in 3°C only and after two warm thermal periods there were 11.8% more seeds germinating.

Withholding of seed germination by partial drying

The germination capacity of seeds used in this experiment was rather high and in the conditions of the warm-followed-by-cold stratification it amounted to 75.5%.

Table 6

The percentage participation of cherry plum seeds of various category at different stages of the warm-followed-by-cold stratification 20°/3°C

Weeks of stratification 20°/3°C	Seed category		
	Intact stones %	Cracked stones %	Germinated %
2+4	100.0	–	–
2+8	50.0	50.0	–
2+12	43.9	45.3	10.8

In Table 6 the percentage participation of seeds of various categories after three consecutive stages of stratification are presented till the appearance of the first germinating seeds. In Table 7 the levels of water content to which the seeds were partially dried after 1 and 7 days are shown, following the three stages of the warm-followed-by-cold stratification mentioned above. From the table it can be seen that 1 day of partial drying of intact stones has lowered the seed water content to 10.1 - 16.8%. Seeds in cracked stones dried much more quickly and their water content dropped to 13.7% and 9.2% after 8 and 12 weeks of stratification at 3°C respectively. Germinated seeds dried even faster which is indicated by the low water content of 8.9%. The drying of stones for 7 days basically equalized the water content in all categories of seeds to 6.9 - 7.7%, regardless whether the seeds were in intact or cracked stones or even germinated.

Table 7

Water content in cherry plum seeds after partial drying in 16°C air current for 1 and 7 days at different stages of the warm-followed-by-cold stratification 20°/3°C

Weeks of stratification 20°/3°C	Duration of partial drying days	Water content in seeds extracted from stones which were:		
		intact %	cracked %	germinated %
2+4	1	11.4	–	–
	7	6.9		
2+8	1	16.8	13.5	–
	7	7.4	7.3	
2+12	1	10.1	9.2	8.9
	7	7.7	7.5	7.5

The viability of seeds after drying did not undergo lowering when intact stones or those starting to crack were dried. Drying of seeds in cracked stones shortly before germination and of germinated seeds led to the dying of the radicle, as contrasted to the cotyledons, the viability of which not affected (indigocarmine test). The above observations were

Table 8

Germination capacity (in %) of cherry plum seeds partially dried at various stages of after-ripening during the warm-followed-by-cold stratification 20°/3°C, stored after drying for 4 or 8 weeks at −1°C and then again stratified at 3°C. The control, not dried and not stored seeds germinated 75.5 %. Values not significantly different at $p=0.05$ are marked with the same letter

Weeks of stratification 20°/3°C	Duration of drying 1 day		Duration of drying 7 days		Means %
	Storage time		Storage time		
	4 weeks %	8 weeks %	4 weeks %	8 weeks %	
2+4 weeks	53.0	59.0	47.5	48.0	51.9b
2+8 weeks	70.5	62.0	69.5	49.0	62.7a
2+12 weeks	43.3	37.9	37.5	39.6	39.6c
Means %	54.3A		48.5B		

confirmed by results of germination tests of the partially dried seeds after 4, 8 and 12 weeks of stratification at 3°C (in a warm-followed-by--cold system 20°/3°C) (Tab. 8, Figs. 5, 6).

A significant influence was exerted on the germination capacity of cherry plum seeds partially dried during stratification by the degree of after-ripening to which the seeds were brought prior to drying. Highest germination percentage was observed in seeds which were partially dried after 2/3 of the stratification period at 3°C, and a lower one after 1/3 of the period. The lowest germination percentages were obtained when the seeds were partially dried during the time first germinating seeds appear (Tab. 8).

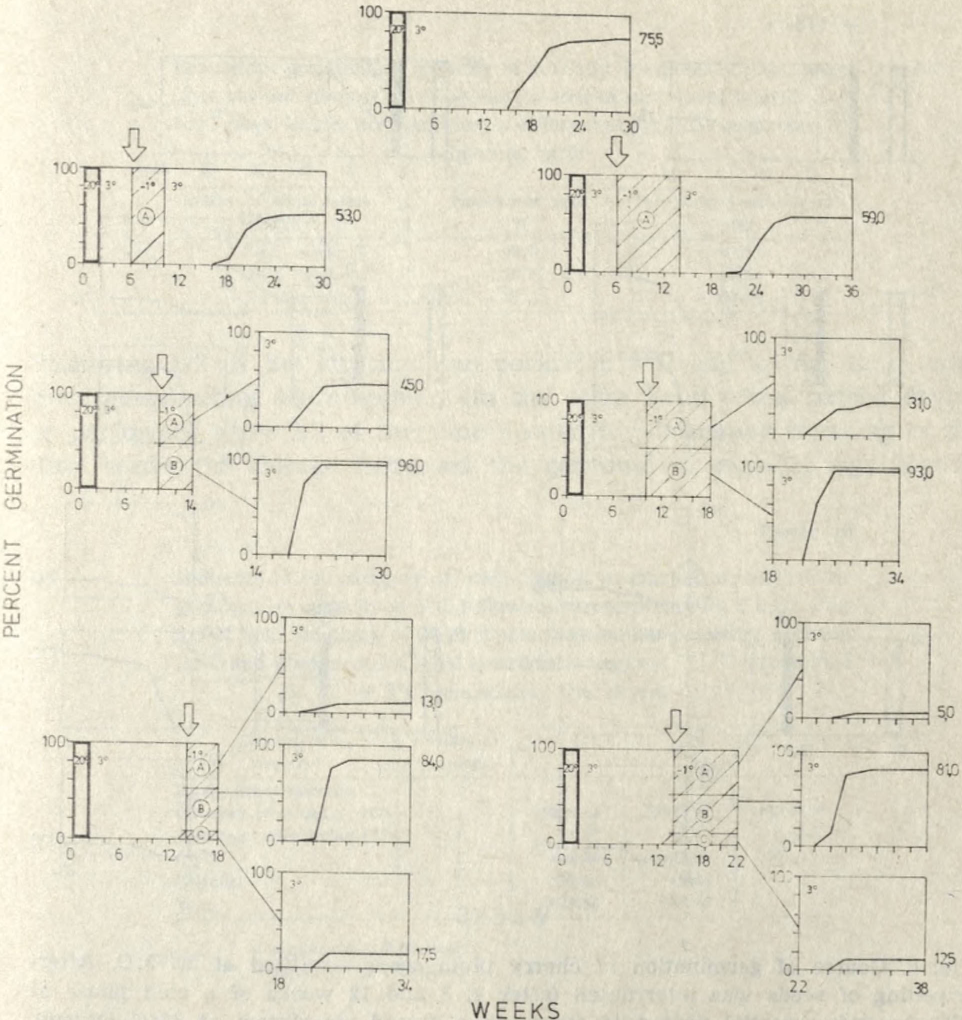


Fig. 5. Course of germination of cherry plum seeds stratified at 20°/3°C. After--ripening of seeds was interrupted (after 4, 8 and 12 weeks of the cold phase at 3°C) by 1-day partial drying of stones in a forced air stream at 16°C (arrow). The dried seeds were stored in a sealed bottles at −1°C for 4 or 8 weeks. After that the cold stratification at 3°C was continued. A — intact stones, B — cracked stones, C — germinated seeds

The germination of seeds, the stratification of which was interrupted by partial drying and storage at −1°C, and which were then returned to the stratification conditions, occurred the earlier the more advanced was the process of after-ripening before partial drying.

Also important was the duration of partial drying (1 or 7 days) and the duration of storage at −1°C (4 or 8 weeks) after partial drying. The percentage of germinating seeds was higher after 1 day of partial

Table 9

Percentage germination capacity of partially dried cherry plum seeds after various stage of after-ripening stored or not stored after drying for 7 days. Values not significantly different at $p=0.05$ are marked by the same letter

Weeks of stratification 20°/3°C	Non-stored seeds %	Seed stored 4 weeks at −1°C %
2+4 weeks	48.7a	47.5a
2+8 weeks	58.7b	69.5c
2+12 weeks	33.1d	37.5d

following 1/3 of the stratification period in 3°C and at the time when first germinating seeds appear. On the other hand when partial drying is performed after 2/3 of the time needed for dormancy breaking of the first seeds, the storage increased the germination capacity significantly

Table 10

Influence of the category of seeds (intacts or cracked stones) on the germination capacity at 3°C following partial drying for 7 days after 2/3 of the cold phase of 20°/3°C stratification has passed (2 weeks in 20°C and 8 weeks at 3°C) and stored for 4 weeks at −1°C or stratified at 3°C immediately after drying

Source of variation	Degrees of freedom	SS	MS	$F_{emp.}$
Experimental variables	3			
Category of stones (C)	1	5823.41	5823.41	137.41**
Treatment after drying (T)	1	18.47	18.47	0.43
C×T	1	442.74	442.74	10.44*
Residual	8	339.05	42.38	
Total	11	6623.68	602.15	

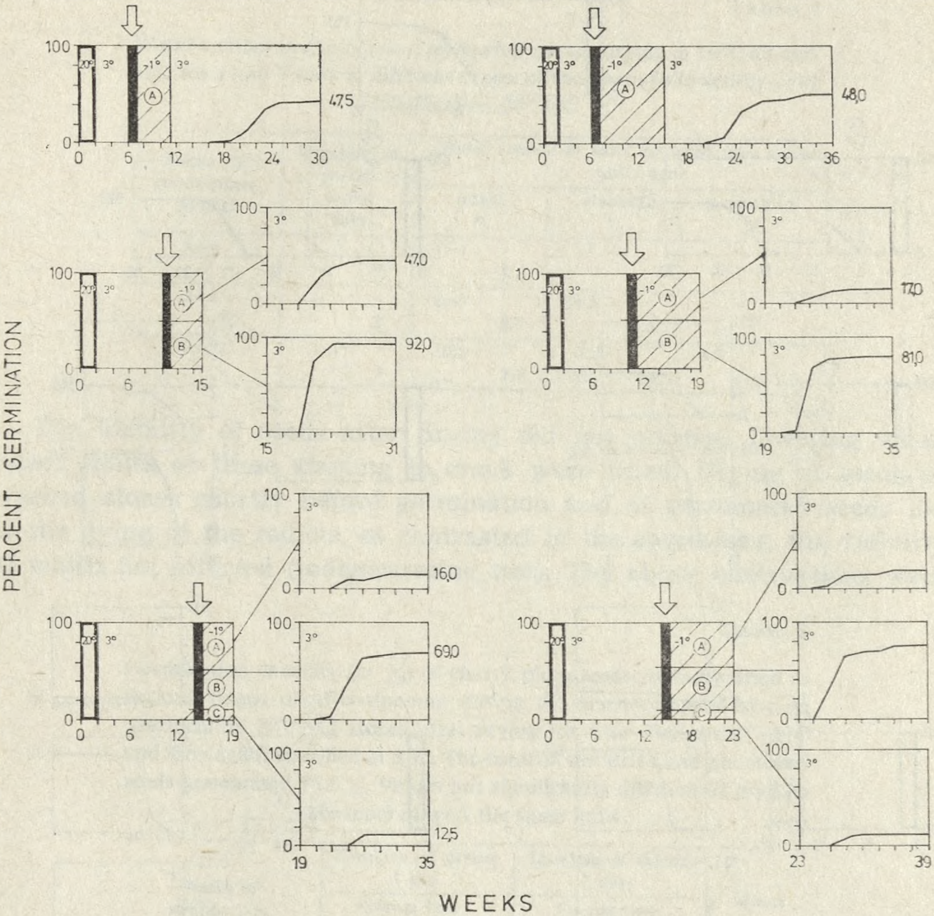
* – significant at 0.05 level

** – significant at 0.01 level

(Tab. 9). A statistical analysis of the results obtained after 2/3 of the stratification time has shown that the major source of variation in germination capacity of partially dried seeds at that time was the category of stones (intact or cracked) in which the seeds were (Tab. 10).

DISCUSSION

Both the studied methods of suspending after-ripening and withholding the germination process in seeds of cherry plum may have a practical application in the case of spring sowing of stratified seeds into the ground. Unfavourable weather conditions (low temperatures, snow, mud etc.), or the need to move the time of sowing of stratified seeds for other reasons, may lead to the unwanted germination of a large pro-



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drying (54.3%) than after 7 days of drying (48.5%, Table 8). Also after the shorter storage period of 4 weeks at −1°C (53.6%) compared to 8 weeks (49.3%).

The most favourable level of germination was obtained therefore when the seeds were partially dried for 24 h after 2/3 of the time needed for the appearance of the first germinating seeds in cold 3°C stratification conditions, and when the seeds were then stored for 4 weeks in seald bottles at −1°C before further stratification at 3°C.

It needs to be pointed out that storage did not differentiate significantly the ability of seeds to germinate after partial drying performed

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following 1/3 of the stratification period in 3°C and at the time when first germinating seeds appear. On the other hand when partial drying is performed after 2/3 of the time needed for dormancy breaking of the first seeds, the storage increased the germination capacity significantly

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Influence of the category of seeds (intacts or cracked stones) on the germination capacity at 3°C following partial drying for 7 days after 2/3 of the cold phase of 20°/3°C stratification has passed (2 weeks in 20°C and 8 weeks at 3°C) and stored for 4 weeks at −1°C or stratified at 3°C immediately after drying

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DISCUSSION

Both the studied methods of suspending after-ripening and withholding the germination process in seeds of cherry plum may have a practical application in the case of spring sowing of stratified seeds into the ground. Unfavourable weather conditions (low temperatures, snow, mud etc.), or the need to move the time of sowing of stratified seeds for other reasons, may lead to the unwanted germination of a large proportion of seeds. The sowing of germinated seeds is practically impossible as it would require individual pricking in of the seeds. One could try to break off the radicles by seeving the seeds and then sowing them us suggested by Zaliwski (1955) and Wierszyłłowski and Katulska (1957), but this method frequently fails (own observation).

It is much more satisfactory to withhold the germination of seeds by lowering temperature below 0°C. In natural conditions a temperature below 0°C can be found in the upper layer of the soil where seeds are and during the winter it can drop substantially and remain so till the spring. At such a time a much too strong freezing of seeds occurs which can result in the autumn sowing being lost. Under controlled conditions (from 0° to −3°C) the injury to seeds caused by freezing is not great and similarily as in the case of partial drying the seeds are conditioned by the stage of the after-ripening process within them. According to Ven'jaminov and Dolmatova (1959) the freezing of stratified seeds of apples and cherries for 100 days at −1°C to −2°C resulted in an increase of the proportion of germinating seeds compared to those which were not frost treated. On the other hand Giersbach and Crocker (1932) have shown an unfavourable influence on the germinative capacity of wild plum seeds of the lowering of temperature below 0°C during stratification. According to these authors a 7-day lowering of stratification temperature to −15°C and a new stratification at 5°C has caused a considerable decrease in the level of seed germination. For example it might be worth reporting that the critical temperature below which seeds of mazzard cherry die during stratification is −11°C at a 41% level of moisture content (according to pilot tests conducted together with Pukacki — unpublished).

From the results presented here it appears that a lowering of stratification temperature from 3° to −1° or −3°C causes also a lowering of the germination capacity of cherry plum seeds by up to a dozen or so percent depending on the degree to which the after-ripening process in the seeds has advanced (Tab. 4). One should also point out that there is a changed level of germination of seed subjected to freezing after 2/3 of the final stage of stratification at 3°C has been completed (prior to germination of first seeds). This is probably associated with the occurrence in the embryo axes of seeds in cracked stones of an increased level of reducing sugars (Simančik 1967, Tylkowski 1985) which may contribute to an increase in the resistance of seeds to low temperatures.

A withholding of the process of after-ripening and of seed germination by their partial drying has been studied by Schander (1955), Stepanov (1955), Visser (1956), Decourtye and Brian (1967), Westwood and Bjornstad (1968), Kamiński (1971 and 1974), Nikolaeva and Ljašuk (1981), Grześkowiak and Suszka (1983). These authors have found that the partial drying of seeds of apple, pear, plum, cherry plum and mazzard cherry does not induce a secondary dormancy in these seeds. The process of dormancy breaking in the seeds is being continued after they are returned to the stratification conditions. Pustovojtova and Oknina (1966) have foud that a slight drying of stratified seeds of cherry plum, plum and apricots has resulted in the accumulation in them of the ribonucleic acid RNA.

The results presented here indicate that the germination capacity of cherry plum seeds in which the germination process has been interrupted by partial drying depends on the degree to which the after-ripening process advanced prior to drying. Most resistant to drying are those cherry plum seeds in which the degree of after-ripening corresponded to 2/3 of the cold phase of stratification needed for the initiation of germination (Tab. 8). Partial drying of seeds in the final stage of stratification was unfavourable for the later germination of seeds. The drying of already germinated seeds has contributed to the occurrence of injuries to the apical meristem of the radicle while at the same time there were no visible injuries to the cotyledons nor to the epicotyl of the embryo. An important role in the retention of germination capacity of partially dried seeds after incomplete stratification of cherry plum seeds is played by the duration of drying. Drying for a shorter period of time was more favourable for the retention of their germinative capacity after return to the stratification conditions than a longer drying (Tab. 8). Extension of the storage time of partially stratified and partially dried seeds of cherry plum has caused a gradual loss of the germination capacity. A similar response was observed in the seeds of mazzard cherry (Grześkowiak and Suszka 1983), which these authors have stored for 48 weeks.

Thus the treatment based on the partial drying of cherry plum seeds to withhold their germination is associated with an irreversible loss of only those seeds which are most advanced in the process of after-ripening and of seeds which have already germinated.

Comparing both these methods of withholding seeds from germination it can be said that a lowering of the stratification temperature below 0°C is more favourable than partial drying. The −3°C temperature was more useful than −1°C for the maintaining of the germination capacity. Extension of the time over which the lower temperature acts on the partially stratified seeds resulted in a gradual increase in the proportion of seeds loosing their germination capacity, similarily as was the case with partial drying of seeds.

While recommending the method of withholding germination of cherry plum seeds during stratification by lowering their temperature below 0°C (from −1° to −3°C) one should remember that the seeds should be sown into the ground while it is still cool additionally protecting the soil with the sown seeds from excessive heating by insolation (Grześkowiak et al. 1983). Such a technique permits the completion of stratification of the seeds in the soil and prevents them from entering a secondary dormancy.

CONCLUSIONS

1. The germination of cherry plum seeds during stratification can be successfully withheld by their partial drying or by lowering their temperature below 0°C.

2. Smallest losses in the germinative capacity of seeds after partial drying have been noted when the partial drying (to 13 - 16% of water content in fresh weight of seeds) has been performed when 2/3 of stratification time in the cold phase at 3°C, needed to obtain first germinating seeds, has passed. The seeds need to be partially dried for 24 h in an air stream at 16°C.

3. A more successfull method of withholding the germination of cherry plum seeds is to lower the stratification temperature to −3°C both when 2/3 of the time needed for stratification at 3°C of the seeds till first ones begin to germinate has passed and when the first germinating seeds have already appeared.

4. In both the situations described above the seeds of cherry plum can be stored for 4 - 8 weeks, after which they have to be returned to the stratification conditions or sown into the ground early in the spring ensuring that the soil temperature is still maintained low. The seed dormancy will be overcome the more quickly the more advanced was the after-ripening process in the seeds prior to partial drying or freezing to below 0°C temperatures.

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Uwarunkowania przebiegu ustępowania spoczynku nasion ałyczy (*Prunus cerasifera* var. *divaricata* Bailey). II. Powstrzymywanie kiełkowania nasion

Streszczenie

Badano wpływ przechowywania częściowo stratyfikowanych nasion ałyczy na ich późniejszą zdolność kiełkowania. Proces ustępowania spoczynku i kiełkowania nasion wstrzymywano przez częściowe odwodnienie (podsuszenie) w wymuszonym prądzie powietrza o temperaturze 16°C (przez 1 dobę lub 7 dób), lub przez obniżenie temperatury do —1° albo —3°C. W obu przypadkach powstrzymywanie kiełkowania zastosowano po 4, 8 i 11 - 12 tygodniach (pojawianie się pierwszych nasion kiełkujących) ostatniej chłodnej fazy stratyfikacji w 3°C.

Najmniejsze straty zdolności kiełkowania nasion po odwodnieniu notowano gdy podsuszanie (do 13 - 16% wilgotności) przeprowadzano po upływie 2/3 czasu potrzebnego do pojawienia się pierwszych nasion kiełkujących w chłodnej fazie stratyfikacji ciepło-chłodnej 20°/3°C (tj. po 2+8 tygodniach).

Bardziej skutecznym od odwodnienia sposobem powstrzymywania kiełkowania nasion ałyczy jest obniżenie temperatury stratyfikacji do —3°C, zastosowane zarówno po upływie 2/3 okresu potrzebnego do ustąpienia spoczynku pierwszych nasion, jak też w początkowym okresie pojawiania się nasion kiełkujących.

W obu przypadkach wymienionych wyżej nasiona ałyczy można przechowywać przez 4 - 8 tygodni, po czym należy je ponownie stratyfikować lub wysiać do gruntu, zapewniając im nadal niską temperaturę. Spoczynek nasion zostanie przezwyciężony tym szybciej, im bardziej zaawansowane w jego ustępowaniu były nasiona przed odwodnieniem lub obniżeniem temperatury poniżej 0°C.

Обусловленность процесса уступания покоя семян алычи (*Prunus cerasifera* var. *divaricata* Bailey) II. Задерживание прорастания семян*

Резюме

Исследовалось влияние хранения частично стратифицированных семян алычи на их позднейшую способность прорастания. Процесс уступания состояния покоя и прорастания семян задерживалось путем частичного обезвоживания (подсушивания) в вынужденном воздушном потоке в температуре 16°C (в течение 1 суток или 7 суток) или прутем снижения температуры до —1° или —3°C. В обоих случаях задерживание прорастания применялось после 4, 8 и 11 - 12 недель (появление первых прорастающих семян) последней холодной фазы стратификации в 3°C.

Наименьшую потерю способности прорастания семян после обезвоживания наблюдали когда подсушивание (до 13 - 16% влажности) проводилось после окончания 2/3 времени нужного для появления первых прорастающих семян в хо-

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лодной фазе стратификации тепло-холодной 20°/3°C (то есть после 2+8 недель).

Более эффективным чем обезвоживание способом задержки прорастания семян алычи является снижение температуры стратификации до −3°C, примененное как после 2/3 времени нужного для уступания покоя первых семян, так и в раннем периоде появления первых прорастающих семян.

В обоих описанных выше случаях семена алычи можно хранить в течение 4 - 8 недель, после чего следует их вновь стратифицировать или высеивать в грунт, обеспечивая им по прежнему низкую температуру. Покой семян будет преодолен тем быстрее, чем более продвинуты в его уступании были семена перед обезвоживанием или понижением температуры ниже 0°C.