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Overcoming of seed dormancy in cherry plum *Prunus cerasifera* var. *divaricata* Bailey*

Abstract

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Seeds of cherry plum were collected in 1982 which was a very hot year. Mean maximal and minimal daily temperature of the month preceding seed collection was 26.0°C and 12.9°C respectively. Both fresh and stored seeds stratified in a warm-followed-by-cold thermal regime (20°/3°) have germinated poorly (2.0 - 32.7%). Seeds sown outside in the spring after prior stratification at 20°/3°C have germinated only 2.0 - 18.7%. Seeds subjected after collection to only warm stratification at 20°C for 2 - 4 weeks and sown outside in the autumn have emerged the following spring 86.7 - 91.4%.

It appears that the decisive influence on the breaking of dormancy in these seeds was exerted by the initially high (20°C) temperature reduced gradually after sowing outside over a period of 5 - 6 weeks to about 3°C, during which time the process of after-ripening continued.

Key words: cherry plum, seed dormancy.

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INTRODUCTION

The low efficiency of vegetative methods propagating root stocks for grafts of noble varieties of plums, apricots, peaches, ornamental varieties of almonds and the red leaved varieties of plums creates a situation where the demand is satisfied primarily by the generative reproduction of *Prunus cerasifera* var. *divaricata* Bailey (Ślaski 1950, Bärtels 1978). Seeds of cherry plum sometimes fail to germinate and the reasons

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lie among others in the climatic conditions which during the ripening of fruits affect the physiological properties of the seeds and in particular the depth of their dormancy. Also many authors seek the causes in a wide range of physiological and morphological variability typical for the species (Wróblewski and Białobok 1946, Ślaski 1949).

In order to obtain germinating seeds of cherry plum it is necessary to stratify seeds after collection. Ślaski (1949) recommends that the seeds be stratified from September in a cool room and then sown in the autumn, when the seeds have already passed at least 2/3 of the dormancy period in favourable conditions of temperature, humudity and aeration. Suszka (1962) and Grześkowiak et al. (1983) believe that good results are obtained if the seeds are sown in the spring after warm-followed-by-cold stratification (20°/3°C) with the warm phase lasting 2 weeks. Thermal stimuli inducting secondary dormancy during stratification successfully increase the ability of mazzard seeds to germinate (Suszka 1967, 1980) however they have no positive effects on the cherry plum seeds (Michalska and Suszka 1980, Tylkowski, unpublished data).

Bogorodickij (1972) and Šolochov et al. (1975) propose that before sowing cherry plum seeds be infiltrated with water or with a solution of growth regulators under a reduced pressure or subjected to the action of superheated steam. The success of these procedures however is doubtful as we were able to establish in our own experiments (Tylkowski, unpublished data).

Making use of the abundant seed crop of cherry plum in 1982 an attempt was made to compare the germination and seedling emergence of partially stratified seeds sown in the autumn with those stratified and sown in the spring.

MATERIALS AND METHODS

Freshly fallen seeds of cherry plum have been collected on August 30th 1982 in Biernatki nr. Kórnik. The stones were divided into two groups. The first i.e. the stones that were not dried, with a water content of 21.0% fresh weight basis (27.7% in the seeds) have been sown in the nursery in 3 replicates (50 stones per replicate) or stratified in a moist mixture of sand with peat (1 : 1 vol.) either at 3°C or at 20°C. After 2, 4, 8 or 12 weeks of stratification at 20°C the stones were sown in the field to a depth of 5 cm and also their stratification was continued at 3°C. When the first radicles started to appear during stratification at 3°C the seeds were subjected to a lowered temperature of −3°C for a few weeks in order to determine its influence on later germination at 3°C (Fig. 1).

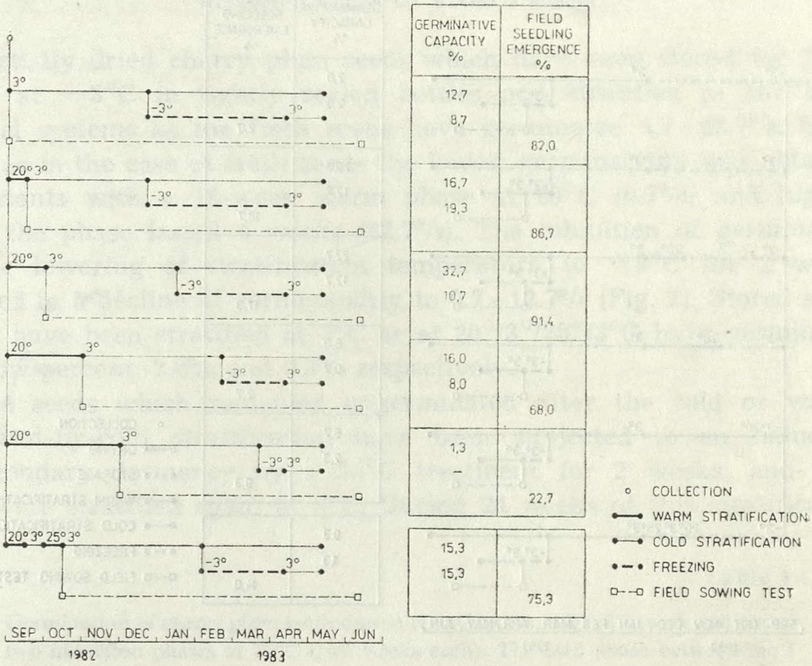


Fig. 1. Design of the stratification and sowing experiments on freshly collected seeds of cherry plum. In the table laboratory results of germination and emergence tests in the nursery are given in percentages

Fresh stones have been stratified also in the 20°/3°/25°C system (two weeks at each temperature) after which they were sown in the field in the autumn or stratified at 3°C as above.

The second group of stones after extraction from the drupes has been dried at room temperature to 9,9% water content in fresh weight (5.6% in seeds) and after a short lasting (2 - 14 weeks) storage at −3°C in tightly closed bottles they were stratified in the same thermal systems as the non-dried seeds mentioned above. Seeds which during the early period of germination have been subjected to a freezing treatment at −3°C for two weeks have been sown (April 10th 1983) in the field or again stratified at 3°C (Fig. 2).

In order to determine the influence of the extended period of seed storage on germination the ability to germinate has been verified during step-wise stratification 20°/3°C (2 weeks at 20°C) started after 2, 6, 10, 12 and 14 weeks of storage in a partially dried state at −3°C.

In the nursery the emergence of seedlings from seeds sown in the autumn after warm stratification has been observed in the spring simultaneously with the emergence of seedlings from stored seeds sown in the spring after prior warm-followed-by-cold stratification (Fig. 1 and 2).

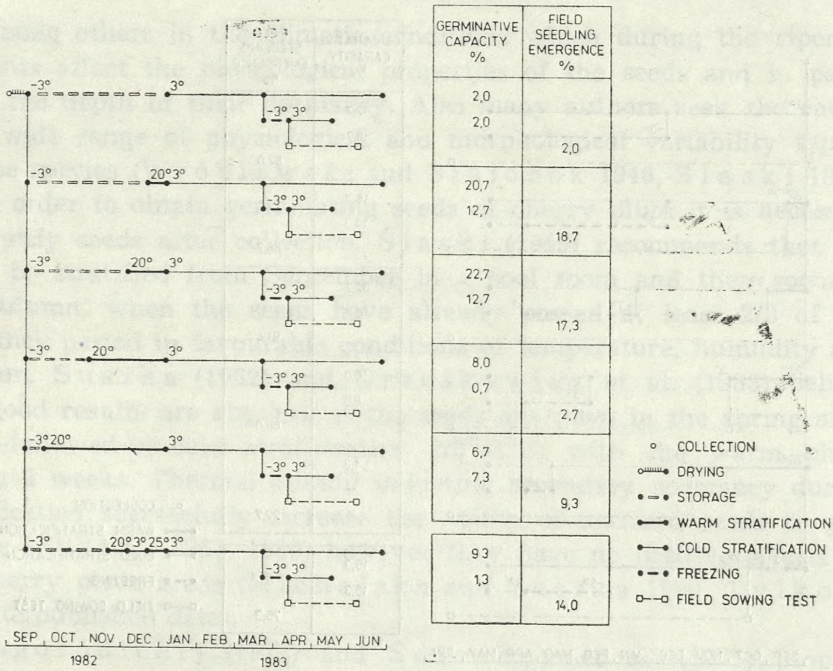


Fig. 2. Design of the stratification and sowing experiments on cherry plum seeds which after collection have been partially dried and stored at −3°C for 2 - 14 weeks. In the table laboratory results of germination and emergence tests in the nursery are given in percentages

RESULTS

STRATIFICATION OF FRESH SEEDS

The laboratory ability of cherry plum seeds to germinate following stratification directly after extraction of the stones from fruits in constant temperatures in the 20°/3°C pattern the warm phase lasting 2 - 12 weeks, was rather low (1.3 - 32.7%) (Fig. 1). The lowest germination at 3°C was observed in the variant stratified in the warm phase for 12 weeks and the highest when the warm phase lasted 4 weeks. Lowering of temperature from 3°C to −3°C at the onset of the germination period lowered the germinability of these seeds to 8.0 - 19.3%.

Stratification of fresh seeds at 3°C without the warm phase also proved unsuccessful, because the seeds germinated only to 12.7%. After freezing at −3°C germination dropped to 8.7%.

The use of the pattern 20°/3°/25°C (two weeks in each temperature) prior to stratification at 3°C has not improved germinability. The seeds germinated 15.3% regardless of whether freezing at −3°C was employed or not.

STRATIFICATION OF STORED SEEDS

Partially dried cherry plum seeds which have been stored for 2 - 14 weeks at −3°C in tightly sealed bottles and stratified in the same thermal systems as the fresh seeds have germinated 6.7 - 22.7%. Similarily as in the case of fresh seeds the lowest germinability was obtained in variants with a 12-week warm phase at 20°C (6.7%) and highest when the phase lasted 4 weeks (22.7%). The inhibition of germination by the lowering of stratification temperature to −3°C for 2 weeks resulted in a decline of germinability to 0.7 - 12.7% (Fig. 2). Stored seeds which have been stratified at 3°C or at 20°/3°/25°/3°C have germinated in a low percent, 2.0% and 9.3% respectively.

The seeds which remained ungerminated after the cold or warm-followed-by-cold stratification have been subjected to an induction of secondary dormancy by a 20°C treatment for 2 weeks, and then they were stratified again at 3°C. During 24 weeks of this stratification

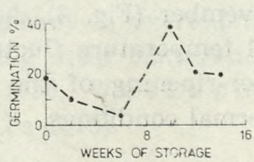
Table 1

Germination of cherry plum seeds during stratification at 20°/3°C with additional two induction phases at 20°C (two weeks each). The cold phase between the I and II induction lasted 20 weeks and between II and III induction as well as after the III induction it was 24 weeks. Before stratification the partially dried seeds have been stored at −3°C

Storage of seeds at −3°C Weeks	Duration of warm phase of stratification at 20°C (I induction) Weeks	Germinative capacity		
		After 20 weeks at 3°C after I induction of dormancy %	After 24 weeks at 3°C after II induction of dormancy %	After 24 weeks at 3°C after III induction of dormancy %
14	0	2.0	8.3	3.3
12	2	20.7	8.3	1.7
10	4	22.7	13.3	20.0
6	8	8.0	0.0	0.0
2	12	6.7	11.7	6.7

at 3°C 0.0 - 13.3% of seeds germinated. Another thermal induction of secondary dormancy and further stratification at 3°C for the same time period led to the germination of a further 0.0 - 20.0% of seeds. Jointly after a warm-followed-by-cold stratification with two thermal inductions of dormancy 8.0 - 56.0% of the partially dried and stored seeds germinated (Table 1).

Fig. 3. Germinability of cherry plum seeds after collection or after partial drying and storage at −3°C for 2 - 14 weeks. The seeds were stratified at 20°/3°C (two weeks at 20°C)



Seeds of cherry plum stored after collection in a partially dried state have responded with a lowered germinability during stratification 20°/3°C (2 weeks at 20°C) from 16.7% (fresh seeds) to 9.3% after 4 weeks and 4.0% after 6 weeks of storage. After 10 weeks of storage the level of seed germination increased to 38.0% and after 12 and 14 weeks it declined again to 20.7% and 18.7% (Fig. 3).

AUTUMN FIELD SOWING OF FRESH AND PARTIALLY STRATIFIED SEEDS

Seeds of cherry plum sown in the field immediately after collection or after warm stratification at 20°C for 2 - 4 weeks have emerged the next spring in a very high percentage (82.0 - 91.4%). When the warm phase has been extended to 8 or 12 weeks, then the ability to germinate dropped to 60.0% and 22.7% respectively (Fig. 1). The use of the 20°/3°/25°C system (two weeks at each temperature) prior to sowing has resulted in 75.2% of seeds germinating.

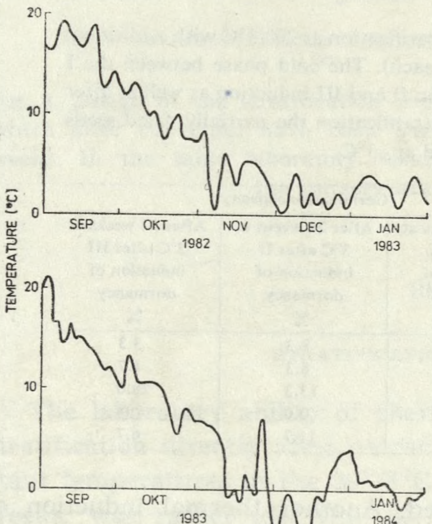


Fig. 4. Pattern of temperature changes in the soil at a depth of 5 cm from September 1st 1982 to January 31st 1983 and from September 1st 1983 to January 31st 1984 at the Kórnik meteorological station

Sowing immediately after collection or after stratification at 20°C for 2 or 4 weeks the natural temperature acting on the seeds in the soil was initially high, close to 20°C, which towards the second decade of September begun systematically declining to about 5°C in early November (Fig. 4). After the next 5 months at the sowing depth the soil temperature fluctuated between 0° and 5°C which allowed for the after-ripening of the majority of the seeds in the most favourable thermal conditions.

SPRING FIELD SOWING OF STRATIFIED SEEDS

Seeds of cherry plum which after collection have been partially dried and stored for 2 - 14 weeks and then stratified at 20°/3°C (2 - 12 weeks at 20°C and 14 weeks at 3°C) and those which prior to spring sowing (April 10th) have been frozen for 2 weeks at −3°C have emerged in the nursery at a comparable level to the seeds which have not been subjected to the freezing treatment (Fig. 2).

Table 2

Seedling emergence in 1983 and 1984 of previously stored seeds of cherry plum stratified at 20°/3°C before sowing in the open in 1983. In the spring of 1984 seeds which failed to germinate in 1983 but remained viable emerged. Before sowing the already stratified seeds have been kept at −3°C for 2 weeks

Storage of seeds at −3°C	Duration of warm phase of stratification at 20°C	Nursery seedling emergence		
		Spring 1983	Spring 1984	Total
Weeks	Weeks	%	%	%
14	0	2.0	56.7	58.7
12	2	18.7	38.7	57.4
10	4	17.3	49.3	66.6
6	8	2.7	58.0	60.7
2	12	9.3	48.0	57.3

The low level of emergence of these seeds was most probably the consequence of low efficiency of the step-wise 20°/3°C stratification. Only after one year of dormancy in the nursery bed the seeds emerged about 50% (Table 2). The course of temperature changes in the soil at the turn of summer and autumn 1983 was characterized similarly as in the previous year (year of seed collection) by a gradual change of temperature from a relatively high one to a low one (Fig. 4). The freezing of soil in December 1983 may have resulted in frost damage of some of the seeds which consequently have not germinated in 1984.

DISCUSSION

Seeds of plants from the genus *Prunus* L. enter dormancy already during fruit maturation on the mother trees (Zagaja 1962, Nikolaeva and Knape 1976, Sińska et al. 1973). Many authors believe that the significant influence on the depth of dormancy is exerted by the pattern of weather conditions prevelant during fruit maturation (Abramov 1952, Von Abrams and Hand 1956, Westwood and Bjornstad 1968, Zaídova 1973, Juntilla 1973).

It appears that in the case of cherry plum seeds collected in late August 1982, the hot weather preceding the time of collection has resulted in the induction of a very deep rest already on the mother shrubs. The mean maximal daily temperature of the first, second and third part of August was very high, amounting to 29.5°, 24,7° and 24.0°C respectively. The mean minimal daily temperature was in the same periods 14.5°, 12.9° and 11.5°C respectively. These seeds which have been stratified in a warm-followed-by-cold thermal system 20°/3°C with the warm phase lasting 2 - 12 weeks have germinated in a very low percentage both when the seeds were stratified immediately after extraction from fruits or after partial drying and storage. It is most likely that the thermal requirements of the seeds, the supply of which would permit a proper course of after ripening, have been different in that year from those normal for seeds ripening in other more cool summer conditions.

The results obtained are in contradiction to those obtained earlier by Suszka (1962, 1964) in his studies on the after ripening of cherry plum seeds, where that author has found that a warm-followed-by-cold stratification of freshly collected seeds guarantees the highest germinability.

In contrast to cherry plum seeds stratified at constant temperatures, first at 20°C and then at 3°C (±0.5°C) those sown into the nursery after collection or after 2 - 4 weeks of stratification at 20°C, have emerged next spring in a very high percent. Zagaja et al. (1961) have established earlier that after autumn sowing of cherry plum directly into the ground 10 days after extracting from fruits and partial drying a greater percentage of seedlings was obtained than following spring sowing of stratified seeds. The interpretation of that result by these authors was restricted only to an observation that an early autumn sowing guaranteed an appropriately long period of after-ripening. It appears however that the ability of seeds to emerge following an autumn sowing was primarily caused by the favourable pattern of thermal conditions existing in the soil at the sowing depth. Starting from the third part of September the temperature of the soil systematically declined till early November, from about 20°C to 5°C. During the lowering of the soil temperature such a range of temperatures acted on the seeds during which the dormancy mechanism got unblocked. The process of after-ripening was later continued at a low temperature. The step-wise stratification in the 20°/3°C system in 1982 has not satisfied these requirements, thus one can assume that the cold phase of stratification at 3°C could be preceded by the action of an initially high temperature in the range 20 - 25°C which then would be gradually reduced by about 3 - 5°C per week till the 3°C level is attained. It would however be necessary to check whether such a thermal system could be utilizable in seeds collected in various years.

It needs to be stressed that the autumn sowing of seeds first stratified at 20°C concerned seeds that have not been initially partially dried. The thermal stratification system proposed above would have to be checked also for seeds that have been stored.

Seeds of cherry plum proved to be more difficult to germinate than seeds of mazzard cherry. Suszka (1962, 1964) has found that the depression of seed germination in mazzard cherry caused by partial drying after collection can be overcome after 8 - 10 weeks of storage. The partial drying of cherry plum seeds has led to a substancial reduction of germinability as in mazzard cherry, but it remained low even after 14 weeks of storage.

CONCLUSIONS

1. Warm-followed-by-cold (20°/3°C) or warm-cold-warm-cold (20°/3°/ /25°/3°C) stratification systems for cherry plum seeds at the constant above mentioned temperatures, with two weeks long warm phases, has not always resulted in a high germinability of the seeds.
2. The highest seed germinability in 1983 has been assured by the autumn sowing of cleaned but not dried seed into the field performed after 2 - 4 weeks of stratification at 20°C immediately after collection.
3. On the basis of results obtained in this study it is proposed to conduct stratification of cherry plum seeds initially at a temperature of 20 - 25°C and then gradually lowering it for 5 - 6 weeks to a temperature of 3°C. The stratification at 3°C should be continued until the apearance of first radicles. The proposed system should be tried on seed material obtained in various years.

SUMMARY

Studies were conducted on the germination and emergence of seeds of cherry plum from the 1982 crop, following an exceptionally hot and dry summer. The seeds have been stratified directly after collection at 20°/3°C or subjected only to a stratification at 20°C and sown outside in the autumn. A part of the seeds was partially dried and stored after collection at −3°C and after a similar stratification at 20°/3°C they were sown in the nursery in spring. The warm phase of stratification lasted 2 - 12 weeks in all the experimental series.

Seed germinability in 1982 of both fresh and stored seeds was

during stratification at the 20°/3°C regime exceptionally low. On the other hand a very high percentage seedling emergence was obtained after 2 - 4 weeks of warm stratification and autumn sowing in the field (86.7 - 91.4%). The further extension of the warm stratification prior to sowing was detrimental.

Stratified seeds sown in the spring have emerged much more poorly (1/5th as well) than after autumn sowing. After one year of dormancy in the nursery bed they have emerged the following spring to about 50%.

It appears that the decisive factor influencing the process of seed dormancy breaking lies in the soil temperature at the sowing depth which was initially high, close to 20°C and which gradually fell to about 3°C over the 5 - 6 weeks after autumn sowing of seeds into the soil. During the winter soil temperature was never below 0°C.

LITERATURE

1. Abramov N. A., 1952. Vlijanie opylitelja na sroki prorastanja semian jabloni. Agrobiologia 5: 111 - 115.
2. Bärtels A., 1978. Gehölzvermehrung. Eugen Ulmer GmbH et Co., Stuttgart.
3. Bogorodickij I. I., 1972. Ustanovka dlja podgotovki semjan drevesnych i kustarnikovych porod. Lesn. Choz. 9: 51 - 53.
4. Grześkowiak H., Miara B., Suszka B., 1983. Long-term storage of seeds of *Rosaceae* species, used as rootstocks for cherry, plum, apple and pear cultivars. Arboretum Kórnickie 28: 283 - 320.
5. Juntilla C., 1973. Seed and embryo germination in *Syringa vulgaris* and *S. reflexa* as affected by temperature during seed development. Physiol. Plant. 29(2): 264 - 268.
6. Michalska S., Suszka B., 1980. Effects of multiple induction of dormancy on germination of seeds of various *Prunus* L. species (experiment 21, continuation and end). In: Suszka B. — Secondary dormancy of seeds of *Prunus* species. Fourth annual report from 1st October 1979 to 30th September 1980. PL-ARS-70, FG-Po-359 (JB-27), Polish Academy of Science, Institute of Dendrology, Kórnik near Poznań, p. 27 - 40.
7. Nikolaeva M. G., Knape D. A., 1976. Vozniknovenie pokoja v semenach jabloni v processe sozrevanija. Bot. Žurnal 61(3): 421 - 427.
8. Sińska I., Grochowska M., Lewak S., 1973. Changes in the endogenous gibberellins content in immature apple seeds. Bull. Acad. Pol. Sci. series Biol. 21: 291 - 295.
9. Suszka B., 1962. Wpływ czynnika termicznego na ustępowanie spoczynku nasion dzikiej czereśni. Arboretum Kórnickie 7: 189 - 275.
10. Suszka B., 1964. Ciepło-chłodna stratyfikacja nasion uprawnych odmian śliw, wiśni i czereśni. Arboretum Kórnickie 9: 237 - 261.
11. Suszka B., 1967. Studia nad spoczynkiem i kiełkowaniem nasion różnych gatunków z rodzaju *Prunus* L. Arboretum Kórnickie 12: 221 - 262.
12. Suszka B., 1980. Secondary dormancy of seeds of *Prunus* species. Fourth annual report from 1st October 1979 to 30th September 1980. PL-ARS-70,

FG-Po-359 (JB-27), Polish Academy of Science, Institute of Dendrology, Kórnik near Poznań.
13. Ś l a s k i J., 1949. Szkółkarstwo Polskie, v. 1, Instytut Naukowo-Wydawniczy Ruchu Ludowego „Polska", Poznań.
14. Ś l a s k i J., 1950. Szkółkarstwo Polskie, v. 2, Instytut Naukowo-Wydawniczy Ruchu Ludowego „Polska", Poznań.
15. Š o l o c h o v L. V., B o g o r o d i c k i j I. I., K o s o v T. F., 1975. Mašina dlja skarifikacii semjan peregretym parom. Les. Choz. 10: 86 - 88.
16. V o n A b r a m s G. J., H a n d M. E., 1956. Seed dormancy in *Rosa* as a function of climate. Amer. J. Botany 43: 7 - 12.
17. W e s t w o o d M. N., B j o r n s t a d H. O., 1968. Chilling requirements of dormant seeds of 14 pear species as related to their climatic adaptation. Proc. Amer. Soc. Hort. Sci. 92: 141 - 149.
18. W r ó b l e w s k i A., B i a ł o b o k S., 1946. Studia nad selekcją podkładek drzew owocowych. Cz. I. Pamiętnik Zakładu Badania Drzew i Lasu w Kórniku, 143 - 170.
19. Z a g a j a S., 1962. After-ripening requirements of immature fruit tree embryos. Hort. Res. 2: 19 - 34.
20. Z a g a j a S., P i e n i ą ż e k S., P i ą t k o w s k i M., 1961. Studia nad przygotowaniem nasion ałyczy (*Prunus cerasifera* var. *divaricata* Bailey) do siewu. II. Wyniki doświadczeń polowych. Prace Inst. Sadown. 16: 67 - 71.
21. Z a í d o v a K. A., 1972. Prorostannja nasinnja jablunu zaležno vid temperaturnych umov. Sadivnictvo. Resp. mižvid. temat. nauk. zb. 16: 67 - 71.

Przezwyciężanie spoczynku nasion ałyczy (*Prunus cerasifera* var. *divaricata* Bailey)

S t r e s z c z e n i e

Przeprowadzono badania nad kiełkowaniem i wschodzeniem nasion ałyczy pochodzących ze zbioru w 1982 roku, który charakteryzował się wyjątkowo ciepłym i suchym latem. Nasiona stratyfikowano bezpośrednio po zbiorze w 20°/3°C lub poddawano stratyfikacji tylko ciepłej w 20°C i wysiewano jesienią do gruntu. Część nasion podsuszono i przechowywano po zbiorze w −3°C, a po podobnej stratyfikacji w 20°/3°C wysiewano wiosną do gruntu. Faza ciepła stratyfikacji trwała 2 - 12 tygodni we wszystkich seriach doświadczalnych.

Zdolność kiełkowania nasion z roku 1982, zarówno świeżych jak i przechowywanych, była podczas stratyfikacji w 20°/3°C wyjątkowo niska. W bardzo wysokim procencie wzeszły natomiast nasiona po 2 - 4-tygodniowej stratyfikacji w 20°C (bezpośrednio po zbiorze) poprzedzającej wczesnojesienny wysiew nasion do gruntu (86,7 - 91,4%). Dalsze wydłużanie ciepłej fazy stratyfikacji wpłynęło niekorzystnie na poziom wschodów.

Nasiona stratyfikowane i wysiane wiosną wzeszły w procencie 5-krotnie niższym niż po wysiewie jesiennym. Po rocznym przelegiwaniu nasiona te wzeszły na następną wiosnę średnio w 50%.

Wydaje się, że decydujący wpływ na proces ustępowania spoczynku nasion ałyczy miała temperatura gleby na głębokości wysiewu, początkowo wysoka, zbliżona do 20°C i stopniowo obniżająca się do około 3°C, przez 5 - 6 tygodni po jesiennym wysiewie nasion do gruntu. W okresie zimy temperatura gleby nigdy nie spadła poniżej 0°C.

Преодоление состояния покоя семян алычи (*Prunus cerasifera* var. *divaricata* Bailey)*

Резюме

Были проведены исследования прорастания и появления всходов семян алычи собранных в 1982 году, который отличался исключительно теплым и сухим летом. Семена стратифицировали непосредственно после сбора в 20°/3°C или подвергали лишь теплой стратификации при 20°C, а затем высеивали осенью в грунт. Часть семян подсушивали и хранили после сбора при −3°C и после аналогичной стратификации при 20°/3°C высеивали весной в грунт. Тепловой период стратификации длился 2 - 12 недель во всех вариантах опыта.

Способность к прорастанию семян собранных в 1982 году, как свежих так и хранившихся, была во время стратификации при 20°/3°C исключительно мала. В то же время в очень большом проценте взошли семена после 2 - 4 недель стратификации при 20°C (непосредственно после сбора) выполненной до ранневесеннего высева семян в грунт (86,7 - 91,4%). Продление фазы тепловой стратификации на более длительный срок неблагоприятно сказывалось на количестве всходов.

Стратифицированные и высеянные весной семена всходили в 5 раз хуже, чем после осенего высева. После годичного лежания в земле эти семена взошли следующей весной в среднем в 50%.

Очевидно решающее влияние на процесс уступания состояния покоя семян алычи имела температура почвы на глубине высева, первоначально высокая, приближающаяся к 20°C и постепенно уменьшающаяся до приблизительно 3°C, спустя 5 - 6 недель после осеннего высева семян в открытый грунт. В зимний период температура почвы ни разу не упала ниже 0°C.

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