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Increase of germinative capacity of mazzard cherry (*Prunus avium* L.)seeds through the induction of secondary dormancy

INTRODUCTION

It is known from studies on seeds of some species from the *Rosaceae* family, as on *Sorbus aucuparia* L. (Flemion 1931), *Rhodotypos kerrioides* Sieb. et Zucc. (Flemion 1933) and on *Prunus persica* (L.) Batsch. (Flemion and de Silva 1960), as well as on seeds of species from other families like *Acer tataricum* L. and *Evonymus europaea* L. (Nikolaeva et al. 1960, 1964) that a temporary increase of tempreature during cold stratification or during the cold phase of warm-followed-by-cold stratification induces a state of secondary dormancy. Similar facts were found in studies on *Prunus avium* L. seeds (Suszka 1967, 1973). Nikolaeva et al. (1960) were the first to observe that after a thermal induction of the secondary dormancy the low-temperature treatment necessary for the after-ripening of the seeds results in the case of *Acer tataricum* and *Evonymus europaea* in an increase of the germinative energy and capacity, in contrast to the non-treated control seeds. Similar effects of the thermal induction of secondary dormancy were found for *Prunus avium* seeds (Suszka 1967), particularily when the thermal stimulus acted after the first two weeks of the cold phase of the warm-followed-by-cold stratification.

The aim of the study reported here was to study more deeply the possibility of increasing the germinative capacity of mazzard cherry seeds and if possible, to eleborate on this basis a new stratification method which would be more effective than the warm-followed-by-cold stratification method developed by the author (Suszka 1962, 1964, 1967, 1970).

MATERIAL AND METHODS

Seed material: *Prunus avium* seeds were collected in three seasons (1967, 1968, 1973) from the same eight individual trees growing in Kórnik, Poland on the experimental fields of the Institute of Dendrology, Polish Academy of Sciences. These seeds were obtained from fruits collected when fully ripe. The seeds were washed out from the fruits without allowing a fermentation of the pulp, cleaned and dried in a shaded airy place at room temperature. The water content of the whole stones in the partially dried state was always in the extremal limits of 8.8 - - 11.0%, calculated on the fresh weight basis, the water content of the seeds deprived of the stone shell was in the limits of 5.9 - 8.7%.

Stone storage: After partial drying the seeds were placed in bothles which after sealing were placed for a short-time storage at a temperature of 0°C±1°C.

Viability estimation: After storage the seeds viability was tested with the help of the indigocarmine embryo staining method (1 : 2000, 20°C, 24 hours). In a similar way the embryos of all sound non germinated seeds were tested after the end of each stratification.

Water content estimation: After storage each seed lot representing a singular tree was tested for its water content by weighing before and after drying for 24 hours at 105°C. The result was calculated on the fresh weight basis.

Seed treatments: Stones from each tree after storage till the end of November were treated separately in the experimental seasons (1967/68, 1968/69, 1973/74) always in three different ways:

a) cold only stratification at 3°C

b) warm-followed-by-cold stratification, with a 2-week warm phase at 20°C and a cold one at 3°C lasting 30 weeks, to allow all sound seeds to germinate at this temperature (Suszka 1962).

c) warm-followed-by-cold stratification as above with a thermal induction phase at 25°C lasting 2 weeks, beginning after 2 weeks of the cold phase at 3°C. After this warm period the temperature of stratification was again lowered to 3°C for 30 weeks. The sequence of temperatures was: 20°C 2 weeks, 3°C 2 weeks, 25°C 2 weeks, 3°C 30 weeks.

In all these treatments the stones were checked at 1-week intervals when stratified at 20° or 25°C, and at 2-week intervals during stratification at 3°C. The stratification medium was a moist sand/peat 1 : 1 (by vol.) mixture. The seed/medium mixture was aerated and moistened if necessary during checking, all germinated and eventually decayed seeds were counted and discarded. The germination criterion was a radicle of 3 mm or longer.

Design of the experiments: see Fig. 1.

Replicates: All viability tests, water content estimations and stratification variants were performed in 4 replicates, with 50 stones in each.

Statistical analysis of the results: The cumulative germinative capacity values were subjected to an analysis of variance following an arcsin transformation. In this analysis 3 variation sources were distinguished: the treatments, the seed collection seasons and the trees,

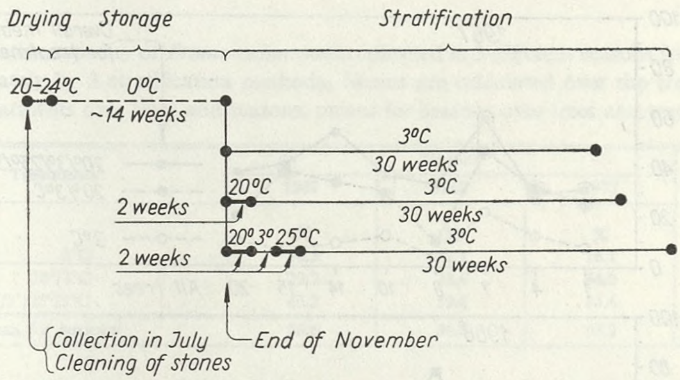

Fig. 1. Design of the experiment in each of the experimental seasons

together with the interactions (treatments × seasons, treatments × trees, seasons × trees and treatmens × seasons × trees). The means calculated for the individual variants, the individual trees, the seasons, the treatments, and the elements of the essential interactions were compared using the Duncan test for the significant differences ($P=0.05$). In the next chapter only significant results are presented.

RESULTS

A. GERMINATIVE CAPACITY

The results are expressed by the germinative capacity values (in percent) obtained from the 4 replicates of each experimental variant, but for more generalizing comparisons means for the different sources of variation were calculated on this basis as well as mean values for the interactions of interest for us (seasons × treatments, trees × treatments) In Fig. 2 the original data for all experimental variants are presented for the seperate seasons of seed collection. In all these seasons the sequence of treatments (stratification methods) from the least to the most effective is always the same: 3°C, 20°/3°C and 20°/3°/25°/3°C. This is reflected by the overall means for these treatments calculated for the separate seasons. The differences between them are always significant. However the differences between the germinative capacity values of the individual experimental variants are in the seasons 1967/68 and 1968/69 between the 3°C and the 20°/3°C treatments insignificant for 1 of the 8 seed sources studied, all other differences of this kind for the remaining 7 trees are significant. The significance of differences between the 20°/3°C and the 20°/3°/25°/3°C treatments depends much more on the season. In 1967/68 seeds of 4 from the 8 trees germinated insignificantly better and 1 of them insignificantly worse after the inductive (20°/3°/25°/3° C) treatment than during the simpler 20°/3° stratification, while seeds of the other

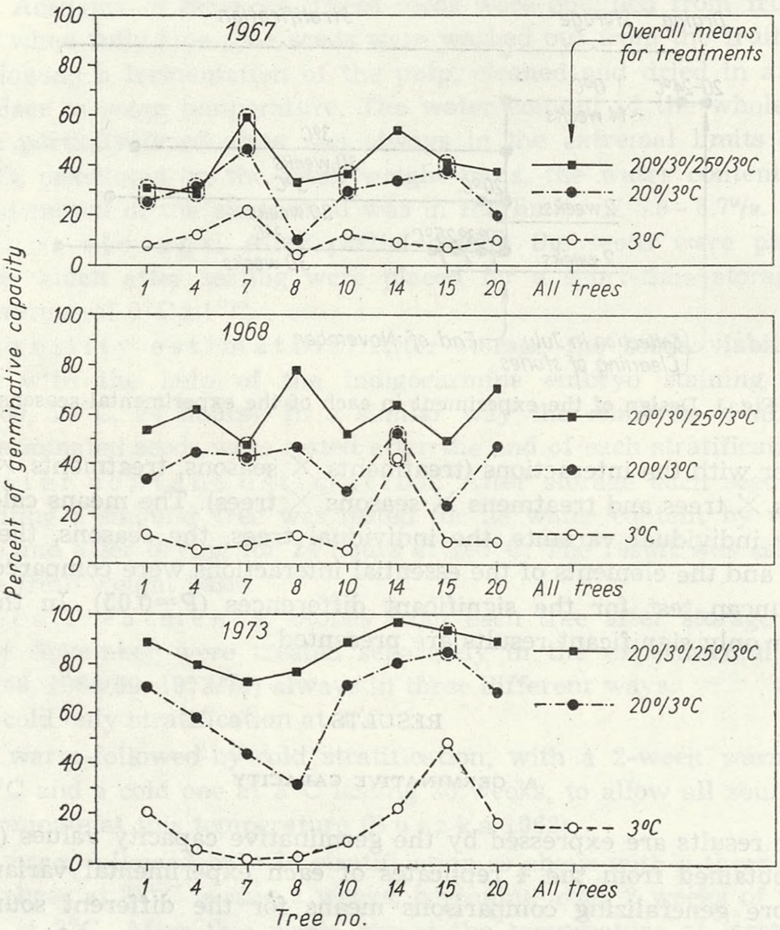

Fig. 2. Germinative capacity of *Prunus avium* seeds collected from 8 individual trees in the years 1967, 1968 and 1973, obtained after a short-term storage during cold only stratification at 3°C, a warm-followed-by-cold stratification at 20°/3°C, and a warm-followed-by-cold stratification interrupted in an early phase of chilling by 25°C for 2 weeks to induce a secondary dormancy. Linked values indicate non-significant differences ($P = 0.05$)

3 trees germinated significantly better. In the other two seasons (1968/69, 1973/74) seeds of all but one single tree germinated significantly better after the inductive treatment.

In a simplified form these data are presented in Table 1 and Fig. 3. The differences between overall means for treatments are all significant as well as between the means in this table, calculated for the treatments in the separate seasons (interaction treatments × seasons).

To show better the results obtained in the different seasons the data from Table 1 are presented in Fig. 4 in another order than in Fig. 3. The means for the same treatments obtained in the 3 seasons lay close

Table 1

Mean germinative capacity of *Prunus avium* seeds collected in 3 different seasons from 8 trees and treated separately by 3 stratification methods. Means are calculated over the trees, the means for treatments over trees and seasons, means for seasons over trees and treatments

Treatments	Seasons 1967	1968	1973	Mean for treatments
	%	%	%	%
3°C	10.3	12.1	16.1	12.8
20°/3°C	29.2	38.6	64.0	43.9
20°/3°/25°/3°C	40.2	59.6	85.6	61.8
Mean for seasons	26.6	36.8	55.2	

to each other in case of the cold only (3°C) stratification. Difference between means for 1967/68 and 1968/69 is insignificant, and on a low level of germinative capacity. The values for the two other treatments are more dispersed and on much higher level, increasing in the sequence:

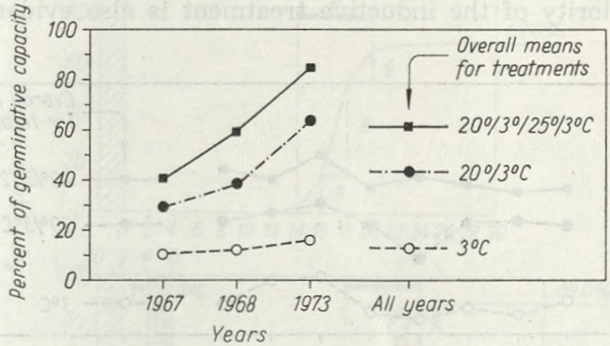

Fig. 3. Effect of the stratification methods on the germination of *Prunus avium* seeds as dependent on the seed collection season. Means are calculated over all the trees, the overall means over trees and seasons

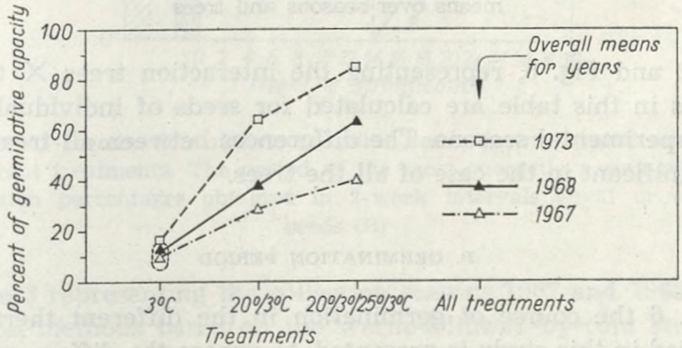

Fig. 4. Effect of the *Prunus avium* seed collection season on the effect of the stratification method. Means are calculated over the trees, the overall means over the trees and treatments. Linked values indicate non-significant difference ($P=0.05$)

Table 2

Mean germinative capacity of *Prunus avium* seeds collected from 8 trees and treated by 3 stratification methods after each of 3 collection seasons. The means within the table are calculated over seasons, the overall means for the treatments over seasons and trees

No. of tree	Treatments		
	3°C	20°/3°C	20°/3°/25°/3°C
	%	%	%
1	13.2	43.3	57.7
4	8.0	44.7	56.8
7	10,5	44.3	59.8
8	6.0	29.7	62.8
10	8.8	43.2	58.7
14	23.0	52.2	71.7
15	21.4	48.7	61.1
20	11.7	45.5	65.8
Mean for treatments	12.8	43.9	61.8

3°C, 20°/3°C, 20°/3°/25°/3°C. The differences between seasons for both the latter treatments are in all cases significant.

The superiority of the inductive treatment is also evident from data

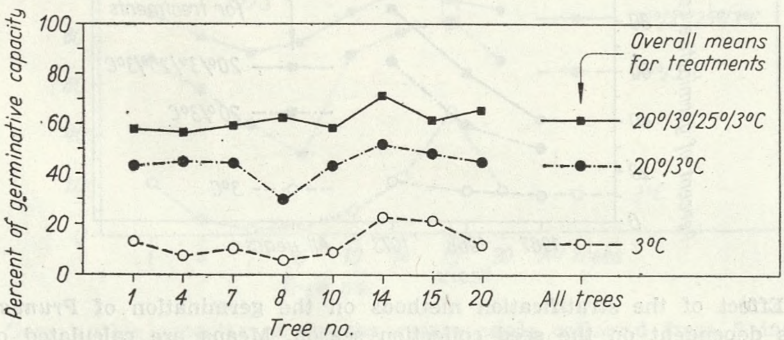

Fig. 5. Effect of the stratification methods on *Prunus avium* seeds collected from 8 trees and treated separately. Means are calculated over the seasons, the overall means over seasons and trees

in Table 2 and Fig. 5, representing the interaction trees × treatments. The means in this table are calculated for seeds of individual trees but over all experimental seasons. The differences between all treatments are always significant in the case of all the trees.

B. GERMINATION PERIOD

In Fig. 6 the course of germination in the different thermal conditions applied in this study is presented, to expose the differences between these treatments, and to explain the data from Table 3. To show these differences we chose as an example the germination of seeds from tree

No. 20 collected in the year 1973, that is in a year with seeds reacting very clearly on the differenciated thermal conditions for their after-ripening. On the cumulative germination curves a major part of them falls in the period of the most energetic germination (A), limited by 2-week intervals with a germination percent equal or bigger than 5% (B).

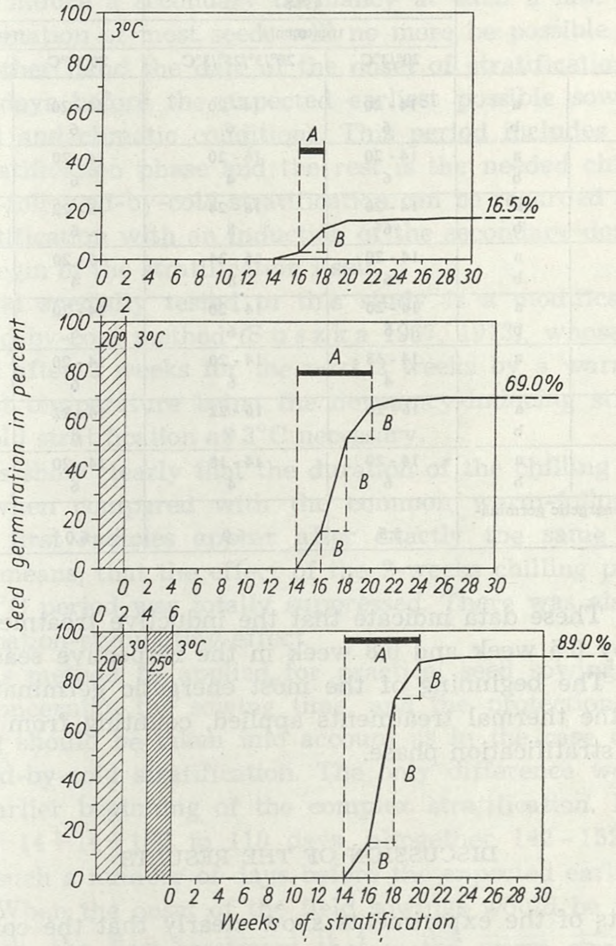

Fig. 6. Course of germination of *Prunus avium* seeds during stratification, affected by the different treatments. The period of the most energetic germination (A) and the germination percentages obtained in 2-week intervals equal or over 5% of seeds (B)

In Table 3 representing the collection seasons 1967 and 1968 and both stratification methods based on the warm-followed-by-cold stratification (with and without an inductive thermal stimulus) the number of weeks in the last cold period is given, between the beginning and termination of the most energetic germination (a) and of the duration of that period

Table 3

Time of the most energetic germination of *Prunus avium* seeds collected in the seasons 1968 and 1973 from 8 trees and stratified by the warm -followed-by-cold 20°/3°C method, and by the 20°/3°/25°/3°C method, in weeks from the onset of the last cold stratification (a). The duration of (a) in weeks = (b).

No. of tree		Seasons 1968 treatments 20°/3°C	Seasons 1968 treatments 20°/3°/25°/3°C	Seasons 1973 treatments 20°/3°C	Seasons 1973 treatments 20°/3°/25°/3°C
1	a	14 - 20	14 - 20	14 - 20	14 - 20
	b	6	6	6	6
4	a	14 - 20	16 - 20	14 - 20	14 - 20
	b	6	4	6	6
7	a	14 - 20	16 - 24	16 - 22	16 - 22
	b	6	8	6	6
8	a	14 - 20	16 - 24	16 - 20	16 - 22
	b	6	8	4	6
10	a	14 - 20	14 - 20	14 - 20	14 - 22
	b	6	6	6	8
14	a	14 - 18	14 - 20	14 - 20	14 - 22
	b	4	6	6	8
15	a	16 - 20	16 - 22	14 - 22	14 - 22
	b	4	6	8	8
20	a	14 - 20	14 - 18	14 - 20	14 - 20
	b	6	4	6	6
Mean time of most energetic germination (in weeks)		5.5	6.0	6.0	6.8

in weeks (b). These data indicate that the inductive treatment prolonged this period by 0.5 week and 0.8 week in the respective seasons: 1967/68 and 1973/74. The beginning of the most energetic germination was not changed by the thermal treatments applied, counting from the onset of the last cold stratification phase.

DISCUSSION OF THE RESULTS

The results of the experiments show clearly that the cold only stratification method is of low effectiveness for Prunus avium seeds and should no more be applied. Significantly better results are provided by the warm-followed-by-cold stratification method (Suszka 1962, 1964, 1967, 1970) consisting of a 2-weeks warm period at 20°C and a subsequent cold one at 3°C. This cold phase of stratification usually lasts 100 - 110 days till the first seeds begin to germinate in such conditions, and when the low temperature is maintained at a constant 3°C level we can expect that in the next 6, sometimes 8 weeks nearly all germinable seeds will germinate. This means that for field sowing the period of emergence of the first radicles in the stratified seed lot should coincide with the sowing date fixed as early as possible. Sowing in the cool early Spring will make a continuation of the seeds after-ripening in the cool soil possible — this should last not less than 6 weeks after sowing. The soil should be protected till the emergence of the first seedlings with straw or other insulating material from being warmed by sunshine. The upper layer of the soil covering the sown seeds can be warmed in April to 30°C or more and this will induce a secondary dormancy at such a late moment, so that the germination of most seeds will no more be possible in this season. On the other hand the date of the onset of stratification should be set 115 - 125 days before the expected earliest possible sowing date in the given soil and climatic conditions. This period includes 2 weeks of the warm stratification phase and the rest is the needed chilling phase.

The warm-followed-by-cold stratification can be regarded as a specific case of a stratification with an induction of the secondary dormancy, namely at the begin of the stratification itself.

The method specially tested in this study is a modification of the warm-followed-by-cold method (S u s z k a 1967, 1973), whose cold phase is interrupted after 2 weeks for the next 2 weeks by a warm period at 25°C, this last temperature being the dormancy-inducing stimulus, making a new cold stratification at 3°C necessary.

Our results show clearly that the duration of the chilling period does not change when compared with the common warm-followed-by-cold method. The first radicles appear after exactly the same number of weeks which means, that the effect of the 2-weeks chilling period acting before the 25°C period was totally suppressed. There was also an unexpected germination-stimulating effect.

Should this method be applied for practical seed sowings, the same precautions concerning the sowing time, and the protection of the soil from heasting should be taken into account as in the case of a normal warm-followed-by-cold stratification. The only difference would consist of an even earlier beginning of the complex stratification. Its duration would be 14+14+14+100 to 110 days, altogether 142 - 152 days, and should begin such a number of days before the expected earliest possible sowing date. When the onset of the field sowings would be planned e.g. for March 10th, the first treatment that is the warm stratification at 20°C should begin between the 9th and the 19th of October of the foregoing year. This would provide the emergence of the first radicles around the planned sowing data, this being a sign for immediate sowing.

We have shown in this study that the positive effect of the dormancy--inducing treatment is strongly season-dependent, indicating the importance of the ecological conditions at the time of the seed formation still on the tree for the ability of seeds to react to the after-ripening conditions. There are seasons after which seeds germinate poorly, which can be hardly corrected by the applied stratification method. There are also other seasons in which most trees produce seeds of a high ability to germinate, specially after the warm-followed-by-cold treatment or in a still higher percent after the more complicated but more effective dormancy-inducing treatment. In such years the differences in the reaction of the seeds to the applied after-ripening conditions become more evident.

It should be pointed out that the excellent results obtained with the seed material used could not be proven in other experiments conducted in our laboratory when seeds were used which were purchased from commercial seed sources after collection, cleaning and drying by professional seed collectors and after storage in not temperature-controlled seedstores of the seed trade organisation. To compare such a seed material with seeds collected and processed by ourselves we stratified 3 different commercial seed lots using the 20°/3°C and the 20°/3°/25°/3°C method with the same timetable as in our experimental work. The results of these tests are presented in Table 4.

Table 4

Germinative capacity of Prunus avium seeds stratified by the warm-followed-by-cold 20°/3°C method, and by the 20°/3°/25°/3°C method. The seed material was purchasted from commercial seed sources

No. of seed lot	Percent values of germinative capacity during stratification at	
	20°/3°C	20°/3°/25°/3°C
1	87.0	73.5
2	70.5	75.0
3	68.5	71.0
Mean germinative capacity	75.3	73.2

This data indicates twice a very slight increase of the germinative capacity after the dormancy-inductive treatment, and in one case even a distinct decline. The means are nearly equal, showing no effect of the method so effective in our experimental work.

We should however bear in mind that the professional seed collectors allow the mazzard cherry seed mass to rot, to facilitate the washing out and cleaning of the seeds from the fruit pulp. Furthermore we do not know the state of the fruit ripeness during collection, and the method of seed drying. What we know are the storage conditions in the trade seedstores which are not controlled in contrast to our cold storage in controlled temperature conditions. All these unknown factors can differ from those used or applied in our work. For this reason we can recommend the application of the newly elaborated warm-followed-by-cold stratification method including an induction of a secondary dormancy in the early phase of chilling only when all conditions of fruit collection time, of seed cleaning, drying and storing be the same as in the here reported study. They are described in the chapter „Materials and methods". On the other hand we can be sure, that in case of unknown seed material even a failure of the proposed new stratification method will not harm the seed material. In fact, it will germinate as after a normal warm-followed-by-cold stratification that is much better than after the traditional cold treatment only.

A very important point is not to forget even during the treatment at 25°C that we never allow the seeds to loose their high water content obtained after the initial imbibition. The stratification medium with the seeds should be always kept moist.

The author wishes to express his gratitude to Miss Leonarda Z i ę t a for the careful compilation of the experimental data.

SUMMARY

Three stratification methods were applied to seed collected in 3 different seasons: 1967, 1968 and 1973, from 8 always the same individual mazzard cherry (*Prunus avium* L.) trees. These seeds were stratified separately in the last days of November of the collection year after short-term storage in sealed bottles at 0° ±1°C in a partially dried condition. The following stratification methods were used: a cold only at 3°C for 30 weeks, a warm-followed-by-cold one with a 2-weeks warm period at 20°C and a chilling period at 3°C for 30 weeks, and a modification of the latter method consisting of an interruption of the chilling phase after 2 weeks by a 2-week warm treatment at 25°C followed again by chilling at 3°C for 30 weeks. The 25°C period was used to induce a secondary dormancy into the already imbibed seed material.

The results indicate a rising effectiveness of the applied stratification methods in the order given above, the last method being highly and significantly effective when compared with both the preceding treatments. A strong dependance of the germinability of seeds, connected with the season of their formation on the trees, became evident. Seeds collected in 1967 germinated worse than in other seasons but preserving the given above order of germinative capacity levels. Seeds from the years 1968 and 1973 germinated much better with a simultaneous better response to both the combined stratification methods, and especially to the dormancy--inducing one. In 1967 only seeds from some trees reacted significantly better to this new stratification method, seeds from the remaining trees germinating better than after the cold and the normal warm-followed-by--cold treatments, but within the limits of insignificance. Seed collected in the two other seasons from all but one tree in each season germinated significantly better after the combined treatment.

The new stratification method did not change the duration of the main chilling period needed for the after-ripening of seeds, the period of the most energetic germination was only slightly prolonged.

It should be pointed out, that the new stratification method will retain its efectiveness only when such factors ist the fruit collection time, the manner of cleaning, partial drying and storing the seed material between drying and stratification be the same as those described in this paper in the chapter "Materials and methods".

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BOLESŁAW SUSZKA

Wzrost zdolności kiełkowania nasion czereśni ptasiej (Prunus avium L.) przez indukcję wtórnego spoczynku

Streszczenie

W Instytucie Dendrologii PAN w Kórniku porównano 3 metody stratyfikacji nasion czereśni ptasiej (*Prunus avium* L.) zebranych z 8 stale tych samych drzew w latach 1967, 1968 i 1973. Stratyfikację nasion rozpoczynano w listopadzie roku zbioru po przechowywaniu w stanie podsuszonym w szczelnie zamkniętych butlach w $0^{\circ} \pm 1^{\circ}C$.

Zastosowano następujące metody stratyfikacji nasion: chłodną w 3°C przez

30 tygodni, ciepło-chłodną z 2-tygodniowym okresem ciepłym w 20°C, a potem z 3°C przez 30 tygodni i metodę ciepłochłodną (jak wyżej), przerwaną po 2 tygodniach fazy chłodnej 2-tygodniowym okresem działania temperatury 25°C, po czym przebiegała nadal stratyfikacja chłodna w 3°C. Temperaturę 25°C zastosowano celowo, do zaindukowania w napęczniałych już nasionach stanu wtórnego spoczynku. Stratyfikacja ta obejmowała więc łącznie kolejno: 2 tygodnie w 20°C, 2 tygodnie w 3°C, 2 tygodnie w 25°C i 30 - 34 tygodni w 3°C.

W wyniku uzyskano narastanie zdolności kiełkowania po zastosowaniu poszczególnych metod stratyfikacji w powyżej podanej kolejności, metoda ostatnia okazała się w porównaniu z obydwiema pozostałymi wysoce i istotnie efektywna. W trakcie badań uwidoczniła się wyraźna zależność zdolności kiełkowania od sezonu formowania się nasion na drzewie. Nasiona zebrane w 1967 r. kiełkowały w niższym procencie niż w pozostałych sezonach, przy zachowaniu podanej powyżej kolejności osiągniętej zdolności kiełkowania. Nasiona z lat 1968 i 1973 kiełkowały w znacznie wyższym procencie przy równoczesnej większej wrażliwości na działanie obydwu kombinowanych metod stratyfikacji, zwłaszcza metody z indukcją wtórnego spoczynku. Po zbiorze w 1967 r. tylko nasiona niektórych drzew reagowały istotnym podwyższeniem zdolności kiełkowania na tę nową metodę stratyfikacji, nasiona pozostałych drzew kiełkowały również lepiej niż podczas chłodnej i zwykłej ciepło-chłodnej stratyfikacji, chociaż bez przekroczenia różnicy istotnej. Nasiona zebrane w dwu pozostałych sezonach ze wszystkich drzew, z wyjątkiem jednego w każdym sezonie, kiełkowały zawsze istotnie lepiej dzięki zastosowaniu stratyfikacji z indukcją wtórnego spoczynku.

Nowy sposób stratyfikacji nie zmieniał czasu trwania głównego okresu oddziaływania chłodu, koniecznego do ustąpienia spoczynku nasion, jedynie okres najbardziej energicznego kiełkowania uległ nieznacznemu przedłużeniu.

Należy podkreślić, że efektywność nowej metody stratyfikacji może być zapewniona tylko wtedy, gdy pora zbioru owoców, sposób oczyszczania nasion, ich podsuszania i przechowywania po podsuszeniu a przed stratyfikacją będzie przebiegać w tych samych warunkach co w przedstawionej tu pracy.

БОЛЕСЛАВ СУШКА

Повышение способности к прорастанию семян дикой черешни (Prunus avium L.) путем индукции вторичного покоя

Резюме

В Институте Дендрологии ПАН в Курнике сравнивались три метода стратификации семян дикой черешни (*Prunus avium* L.), собранных с тех же самых восьми деревьев в 1967, 1968 и 1973 годах. Стратификация семян начиналась в ноябре года сбора после хранения их в сухом состоянии в герметически закрытых бутылях при температуре 0°±1°C. Были применены следующие методы стратификации семян: холодный при 3°C в течение 30 недель, тепло-холодный с 2-недельным теплым периодом с температурой 20°C, а потом 3°C в течение 30 недель, и тепло-холодный метод (как выше), при котором 2-недельная холодная фаза сменялась 2-недельным периодом с температурой 25°C, после чего опять происходила холодная стратификация при 3°C. Температура 25°C была применена специально с целью индуцирования в уже набухших семенах состояния вторичного покоя. Таким образом эта стратификация охватывала в общем итоге 2 недели в температуре 20°C, 2 недели при 3°C, 2 недели в 25°C и 30 - 34 недели в 3°C.

В результате было получено возрастание способности к прорастанию после применения каждого отдельного метода стратификации в вышеприведенной очередности, причем последний метод оказался высоко эффективным по сравнению с двумя остальными. В ходе исследований обнаружилась явная зависимость способности к прорастанию от сезона формирования семян на дереве. Семена, собранные в 1967 году, дали более низкий процент прорастания, чем семена в остальных сезонах, при сохранении поданной выше очередности достигнутой способности к прорастанию.

Процент прорастания семян, собранных в 1968 и 1973 годах, был значительно высший, и эти семена были одновременно более чувствительны к действию обеих комбинированных методов стратификации, особенно к методу с индукцией вторичного покоя. Из сбора семян в 1967 году только семена некоторых деревьев реагировали на этот новый метод стратификации существенным повышением способности к прорастанию, семена остальных деревьев прорастали также лучше, чем при холодной и обычной тепло-холодной стратификации, хотя это не выходило за пределы существенной разницы. Семена, собранные в двух остальных сезонах со всех деревьев, за исключением одного в каждом сезоне, прорастали всегда значительно лучше, благодаря применению стратификации с индукцией вторичного покоя.

Новый метод стратификации не изменяет времени длительности главного периода действия холода необходимого для устранения покоя семян, только период наиболее энергичного прорастания подвергся незначительному продлению.

Следует подчеркнуть что эффективность нового метода стратификации может быть обеспечена только тогда, когда время сбора плодов, способ очистки семян, их подсушки и сохранения после подсушки перед стратификацией будет протекать в тех самых условиях, которые представлены в настоящей работе.