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Conditions for the after-ripening of cherry plum (*Prunus cerasifera* var. *divaricata* Bailey) seeds. I. Quantitative changes in reserve materials during the after-ripening of seeds under various temperature regimes*

Abstract

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Quantitative changes were observed in lipids and reducing sugars in embryo axes, endosperm and cotyledons of cherry plum seeds stratified in three different thermal regimes. Under the same conditions of stratification the uptake of oxygen by isolated embryo axes and the influence of these conditions of the permeability of cell membranes have been investigated.

It was found that during stratification at 3°C (low germinability) the content of lipids and reducing sugars in the embryo axes declines slowly and gradually while during the warm phase of the warm-followed-by-cold stratification (20°/3°C, high germinability) the level of reducing sugars declines rapidly till complete disappearance (these sugars are used up in the respiratory processes) and the content of lipids somewhat increases. In the warm phase of the stratification the permeability of cell membranes is lower compared to that in seeds stratified at a low temperature.

Additional key words: dormancy, lipids, reducing sugars, respiration, permeability of cytomembranes.

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INTRODUCTION

A fair proportion of plants form seeds that are characterized by a longer or shorter dormancy which is overcome during stratification. According to Amen (1968) the dormancy of seeds is controlled by plant hormones differing in their mode of action.

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He postulates that the dormant condition is associated with an unfavourable ratio of the components in an inhibitor-promotor complex.

According to Taylorson and Hendricks (1977) the cause of dormancy lies in the lack of integration within an associated metabolic system. This integration requires an exchange of metabolites between cell organelles such as mitochondria, etioplasts and glycosomes. This exchange is probably controlled by the action of growth regulators and phytochrome on the degree of permeability of organelle membranes. According to these authors non-integration of the metabolism is the probable cause of the dormant state.

Lewak et al. (1975) have studied the primary causes of dormancy in seeds of apples from the metabolic point of view. According to them the main condition for the overcoming of dormancy is the hydrolysis of reserve proteins as a consequence of which synthesis of new proteins needed for germination becomes possible. The maintenance and overcoming of dormancy is metabolic in nature (Ryć and Lewak 1982).

The latest studies of Bouvier-Durand et al. (1984) indicate however that neither proteolysis nor the hydrolytic decomposition of starch taking place in embryo axes of stratified seeds and apple embryos are in any way associated with the overcoming of dormancy.

In his investigations on the after-ripening of seeds from the genus *Prunus* Suszka (1962, 1967) has found that the employment of a short lasting stratification of stones (of mazzard cherry, cherry plum and others) at a higher temperature prior to cold stratification significantly improves the germinability of seeds compared to the cold stratification only.

The aim of the investigations undertaken by me was to determine the quantitative changes in the lipids and reducing sugars in stratified cherry plum seeds at three different temperature regimes differing in effectiveness, particularily during the early stage of stratification which is decisive for the later after-ripening of seeds in the cold. Studies were also conducted on the influence of the thermal conditions employed on the oxygen uptake of embryo axes and on the permeability of cell membranes of the stratified seeds.

MATERIAL AND METHODS

For the studies of quantitative changes in lipids, reducing sugars and in the permeability of cell membranes use was made of a mixture of three commericial lots of cherry plum seeds from the 1980 collection. The mean water content in the fresh weight of whole stones was 12.7%, in the shells 14.4% and in the seeds 7.0%. The seed viability was high, 99.5%.

For the studies on the intensity of respiration of embryo axes use was made of seeds collected on the 2nd of September 1982 in Kórnik. Stones after partial drying have been stored for 16 months in tightly sealed bottles at −3°C. The moisture content of the stones was 9.7% (6.0% of the seeds) and the viability was 100%.

The stones were stratified in three thermal systems. System A at 3°C, system B at 20°/3°C the warm period lasting two weeks and system C 20°/3°/25°/3°C each of the first three phases lasting 2 weeks (6 weeks preceding the final cold stratification).

DETERMINATION OF THE CHANGES IN LIPID CONTENT

Lipids have been extracted by the method of Kates (1972) separately from 50 embryo axes, from 30 endosperms and from 30 single cotyledons from 30 seeds, each in 3 replicates. The embryo axes, endosperms and cotyledons have been ground in a mortar respectively in 2, 5 and 8 ml of isopropanol and then extracted two times for 30 minutes each on a shaker adding 20 ml of chloroform-methanol 2 : 1 mixture. The content of lipids was determined by weight after evaporation of the solvent on a vacuum (0.1 atm) evaporator at 70°C.

DETERMINATION OF THE QUANTITATIVE CHANGES IN THE REDUCING SUGARS

Reducing sugars have been determined by the method of Somogyi (1945). Embryo axes (in 3 replicates with 20 each) have been ground in 2 ml of distilled water for 5 min. To 0.5 ml of extract 0.5 ml of 10% $ZnSO_4$ and 0.5 ml 0.5 M NaOH have been added and after 5 minutes of protein precipitation the samples were filtrated into test-tubes. To 1 ml of filtrate 1 ml of a copper-vinyl reagent was added and boiled for 10 minutes on a water bath, after which the sample was quickly cooled to room temperature. After adding 1 ml of an arseno-molibdenian reagent and supplementing to 10 ml with distilled water colorimetrically the content of reducing sugars was determined at a wavelength of 500 nm of a "Specol" photocolorimeter. The result was read off from a calibration curve drawn on a basis of known glucose concentrations. The content of reducing sugars in the endosperm was determined for 3 replicates with 10 endosperms each ground with water for 10 minutes and the content of these sugars in the cotyledons was also measured in 3 replicates with 10 single cotyledons each (from 10 seeds), ground in 10 ml of water for 5 minutes.

DETERMINATION OF THE ELECTROLYTIC CONDUCTIVITY OF WATER LEACHATES

The electrolytic conductivity of solutions diffusing into distilled water from tissues of stratified seeds of the cherry plum has been measured using a Hungarian, Radelkis conductometer OK-102/1. The organs of embryos or parts of seeds (20 embryo axes, 10 single cotyledons from 10 embryos, the endosperm from 10 seeds) isolated during stratification have been covered in 30 ml of trice distilled water, all in three replicates. The measurement of conductivity of these solutions has been made in μS after 24 h of exoosmosis at a temperature of 20°C.

DETERMINATION OF THE RESPIRATION INTENSITY OF EMBRYO AXES

Embryo axes were isolated from dry seeds (before stratification) and at weekly intervals during stratification, using 3 replicates 40 embryo axes each. The intensity of oxygen uptake by them has been measured and the respiratory quotient (RQ) calculated. The measurements were conducted at 20°C using a Warburg respirometer

in the presence of 20% KOH. The amount of oxygen absorbed is presented as μl O_2/h/40 embryo axes. Separate measurements of respiration intensity were made for embryo axes isolated from intact stones and from stones cracked during stratification.

RESULTS

The course of germination of cherry plum seeds, used for the studies on changes in lipids and reducing sugars content and for the electrolytic conductivity of water leachates, as it progressed during stratification in three different thermal regimes is

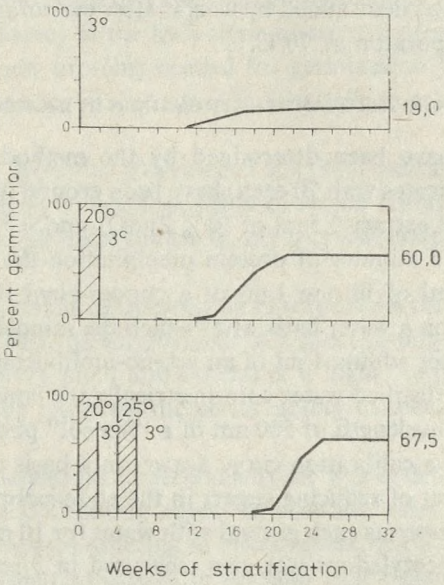

Fig. 1. Course of germination of cherry plum seeds stratified in three different thermal conditions

presented in Fig. 1. The obtained levels of germination were 19.0% during stratification at 3°C (system A), 60.0% at 20°/3°C (system B) and 67.5% at 20°/3°/25°/3°C (system C).

CHANGES IN THE CONTENT OF LIPIDS

Changes in the content of lipids in the dry weight of endosperm, cotyledons and embryo axes during stratification of the seed in the above mentioned thermal regimes are presented in Fig. 2.

The content of lipids in individual organs of seeds was differentiated from the very onset of stratification. In the dry weight of the endosperm there was relatively little of them, about 40%. In the dry weight of cotyledons, the main storage organs for seed of the species, lipid content attained 51.5%. The highest lipid content was observed in the embryo axes, there being as much as 60% of lipids per unit dry weight.

Changes in the content of lipids in the endosperm of stratified seed progressed in the direction of a small decline during dormancy breaking regardless of the thermal regime employed. After 21 weeks of stratification in the C system the content of lipids in the endosperm of intact stones was lower than the initial value by about 6.1%, in the endosperm from cracked stones by 7.3% and in the endosperm of germinating seeds by 9.3%.

In the cotyledons the lipids remained practically at quantitatively unchanged levels throughout the duration of stratification (Fig. 2).

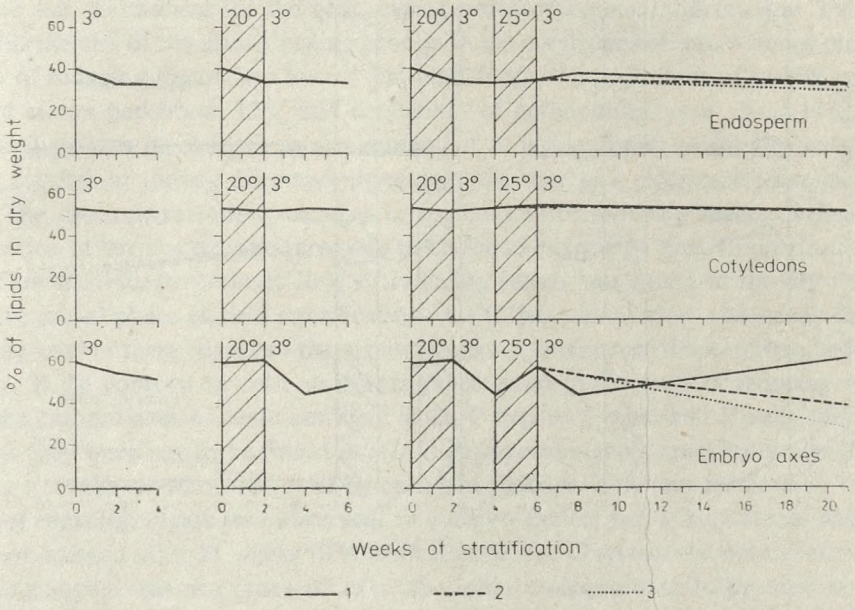

Fig. 2. The course of changes in the levels of lipids in the embryo axes, endosperm and cotyledons of cherry plum seeds stratified in various thermal regimes

1 – Seed from intact stones, *2* – Seed from cracked stones, *3* – Germinated seed

In the embryo axes during cold only stratification at 3°C (system A) a slow systematic drop in the level of lipids was observed which after 4 weeks declined by about 9% relative to the initial value. In the warm phase (20°C) of the warm-followed-by-cold stratification (system B) the level of lipids in the embryo axes did not undergo any quantitative changes. However after the lowering of the temperature to 3°C the decline in lipid level was distinct, so that together after 4 weeks (2 weeks at 20°C and 2 weeks at 3°C) the overall level was 15% below the initial value. After induction of the secondary dormancy with a 25°C temperature (system C) an increase was observed in the content of lipids in the embryo axes to a level that existed before stratification. After the following lowering of temperature to 3°C a substantial decline in the level lipids was observed in seeds with a much advanced after-ripennig, first in cracked stones and then in germinating seeds. It needs to be stressed that the content of lipids

in the embryo axes of seeds that remained dormant continued unchanged, which is indicated by the fact that it was almost the same as at the beginning even after 21 weeks of stratification in the C system (Fig. 2).

CHANGES IN THE LEVELS OF THE REDUCING SUGARS

Quantitative changes in the levels of reducing sugars in embryo axes, cotyledons and endosperm of the seed during the overcoming of their dormancy in three different thermal regimes of various effectiveness are presented in Fig. 3.

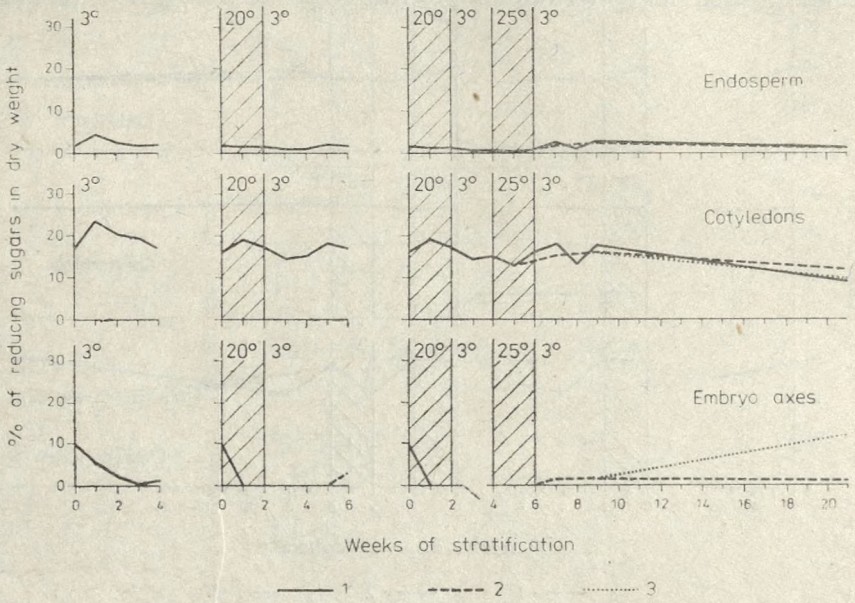

Fig. 3. The course of changes in the levels of reducing sugars in the embryo axes, endosperm and cotyledons of cherry plum seeds stratified in various thermal regimes

1 – Seed from intact stones, *2* – Seed from cracked stones, *3* – Germinated seed

The percentage content of reducing sugars in the dry weight of individual organs of the seeds was very diversified. In the endosperm (together with the seed coat) the content of these sugars was only about 2% of the dry weight and it basically remained unchanged throughout the duration of the stratification.

The cotyledons initially held about 17% of reducing sugars in the dry weight. After the first week of stratification at 3°C the content of reducing sugars increased to 24% and then it gradually declined for the next three weeks till it reached the initial level.

During stratification at 20°C (in system B) after the first week of action of this temperature the content of reducing sugars increased insignificantly and only temporarily attaing a level of about 19%. After lowering of the temperature to 3°C the level continued to decline to about 15% after 3 weeks (2 weeks at 20°C and 1 week at 3°C). The further action of the low 3°C temperature on imbibed seeds caused

another increase in the level of reducing sugars to about 18% after 5 weeks of warm--followed-by-cold stratification.

The use of the high 25°C temperature after 4 weeks of warm-followed-by-cold stratification (system C) caused a lowering of the content of sugars in the cotyledons to about 13% after one week at that temperature. In the sixth week of stratification in that thermal regime (system C) the onset of stone cracking was observed in some of the seeds (crack 0.05-0.1 mm wide). The content of reducing sugars in the cotyledons of seed from cracked stones was 2 - 3% lower than in the cotyledons of seed from intact stones after the same stratification treatment. This difference was maintained for the next several weeks of stone stratification at 3°C. Towards the end of the after-ripening process in the cotyledons of intact stones the content of reducing sugars was lowest (arround 10%), the cotyledons of seed from cracked stones had about 12% and cotyledons of germinating seeds about 11%. The overall pattern of changes in the content of reducing sugars in the dry weight of the cotyledons during dormancy breaking was that of a progressive decline.

The most characteristic changes in the content of reducing sugars during stratification at various temperatures was to be found in embryo axes. In dormant seeds (before stratification) about 10% of reducing sugars was found in the dry weight. In the initial phase of cold stratification at 3°C there was a slow and steady decline in the level of these sugars so that after 4 weeks only traces of them were to be found (Fig. 3). In contrast to cold stratification the drop in the level of reducing sugars in the embryo axes of seeds stratified at 20°C was very rapid and already after one week they were not to be found at all. In embryo axes from cracking stones jointly after 6 weeks of warm-followed-by-cold stratification a certain increase in the level of reducing sugars was observed. In embryo axes of seeds from stones that were not cracked after 21 weeks of stratification in the C system the occurrence of reducing sugars was not observed after the initial dissapearance in the first week at 20°C. In the embryo axes of germinating seeds held in this thermal regime the level of reducing sugars was several times higher than in the embryo axes from cracked stones (Fig. 3).

CHANGES IN THE PERMEABILITY OF CYTOPLASMIC MEMBRANES

In Fig. 4 the course of changes in the electrolytic conductivity of water leachates from the endosperm, embryo axes and cotyledons are shown. As it can be seen from this figure, at the higher stratification temperature (20° or 25°C) the exoosmosis of the electrolytes from the endosperm and cotyledons is less intense than from the seeds held at 3°C. As the process of dormancy breaking progresses at 3°C, through stone cracking to germination, there was observed an increase in the intensity of electrolyte diffusion from the embryo axes and from the endosperm into the solution, as was indicated by the conductivity of the water leachates. Such a relationship was not observed in the case of the cotyledons. After 21 weeks of stratification of the seeds in the C system no obvious differences were observed between the conductivity of electrolytes from cotyledons of seeds from intact stones and from germinating seeds.

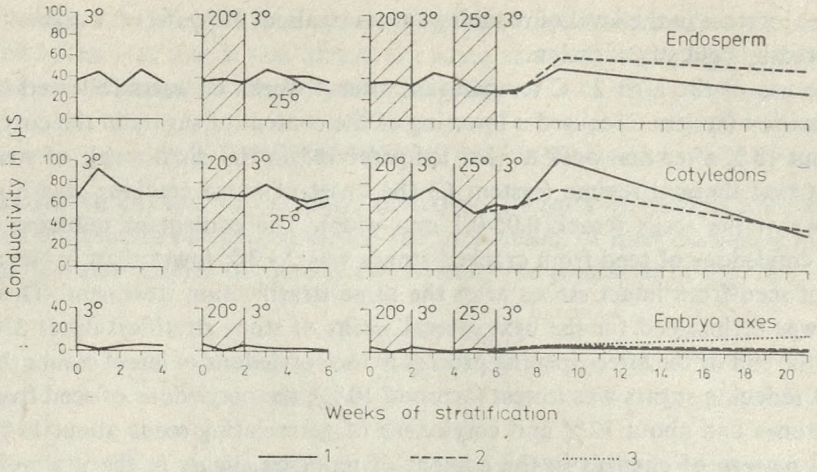

Fig. 4. The electrolytic conductivity of water leachates from the endosperm, cotyledons and embryo axes of cherry plum seeds stratified in various thermal regimes. The arrow indicates the level of exoosmosis from seeds stratified at 25°C

1 – Seed from intact stones, *2* – Seed from cracked stones, *3* – Germinated seed

CHANGES IN THE INTENSITY OF RESPIRATION BY EMBRYO AXES

The course of oxygen uptake by embryo axes and the germinability of the seeds of cherry plum in three different thermal regimes is shown in Fig. 5.

The effectiveness of the various thermal regimes of stratification was as follows: in system A – 8%, in system B – 58.5% and in system C – 61.0% of seeds germinated.

During 4 weeks of stratification at 3°C there occurred a slow increase in the oxygen uptake while the respiratory quotient remained unchanged, being both for dry seeds and those stratified for 4 weeks equal to 0.65.

During the 2 week stratification at 20°C (system B) there was observed a gradual, slow increase in the oxygen uptake by the embryo axes from 3.8 µl O_2 to 5.2 µl O_2. After lowering the temperature to 3°C the intensity of respiration at first rapidly increased attaing after 2 weeks a level of 15.4 µl O_2 and then became lowered after a further 2 weeks for a level of 12.2 µl O_2. The respiratory quotient of embryo axes from seeds stratified at 20°C increased from 0.65 (for dry seeds) to 0.90 after one week of stratification at that temperature, then went down to 0.47 in the second week. After the change of temperature from 20° to 3°C the respiratory quotient increased linearly attaing a value of 0.96 after 4 weeks at 3°C.

The use of the thermal stimulus of 25°C (system C) has substantially lowered the oxygen uptake from 15.4 µl O_2 to 6.4 µl O_2 after the first week of acting with the temperature. Embryo axes from seeds in cracked stones, which appeared in the second week at that temperature, took up much more oxygen (12 µl O_2) than embryo axes isolated from seeds in intact stones (7 µl O_2) stratified for the same period of time. A further stratification at 3°C resulted in a substantial increase of oxygen

uptake by embryo axes from cracked stones (26.6 µl O_2 after 2 weeks) while the oxygen uptake by embryo axes from intact stones practically remained the same (a small increase from 7.0 to 8.6 µl O_2 after 2 weeks).

The respiratory quotient of the embryo axes from cracked stones did not change when the temperature of 25°C was employed after the warm-followed-by-cold stra-

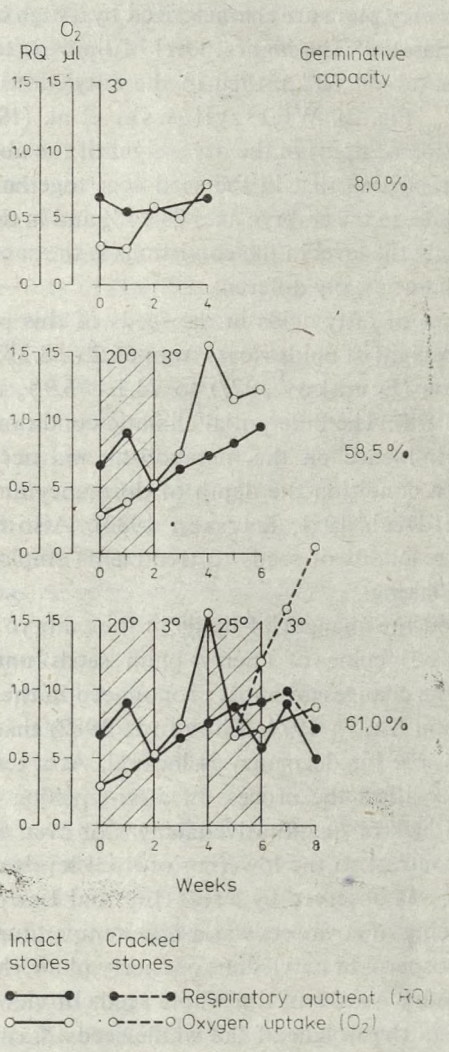

Fig. 5. Oxygen uptake and changes in the value of the respiratory quotient RQ of embryo axes of cherry plum seeds stratified in three different thermal regimes differing in effectiveness for germination

tification of 20°/3°C and it stayed at 0.90 after 2 weeks at 25°C. After lowering of the temperature to 3°C the respiratory quotient increased after 1 week to 0.98 and then declined to 0.70 after 2 weeks.

The respiratory quotient of embryo axes from intact stones attained a level of

0.56 after 2 weeks in 25°C. When the temperature was lowered to 3°C it was observed that similarily as was the case in cracked stones the initial increase in the respiratory quotient to 0.90 was followed by a drop to 0.50 (Fig. 5).

DISCUSSION

Dormant seeds of cherry plum are characterized by a high content of lipids which are the basic storage material. The highest level of lipids is to be found in the dry weight of embryo axes (about 60%), then in the cotyledons (about 53%) and in endosperm (about 40%, Fig. 2). Wierszyłłowski et al. (1963) report a completely different participation of lipids in the dry weight of the above mentioned tissues of cherry plum seeds reporting that in the seed coat together with the endosperm there is only 0.70% of fats, in the embryo axes 23.94% and in the cotyledons 52.92%. Of the data reported only the level in the cotyledons is the same, while for the other tissues the values are diametrically different.

The main component of fatty acids in the seeds of this plum is the oleic acid. Its content in the total weight of lipids varies from 65.2 - 68.3% in the east European regions of Soviet Union (Ermakov 1977) to 74.1 - 76.9% in Poland (Kawecki and Jaworski 1977, 1978). The differential climatic conditions of seed maturation undoubtely have an influence on the metabolism and accumulation of reserve materials, which in turn condition the depth of dormancy and rate of overcoming it (Gassner 1938, Hilditch 1951, Karssen 1982). Also for the same reasons there can be different reactions of seeds to treatments employed before or during stratification, such as soaking.

The present study on the changes of lipids in the embryo axes, endosperm and cotyledons during after-ripening of cherry plum seeds under different thermal regimes indicates that the changes are most pronounced in the embryo axes (Fig. 2). It is belived (Mayer and Shain 1974, Thevenot 1982) that it is in embryo axes that the system responsible for dormancy is located. At a temperature 20°C or at 25°C which significantly affect the process of after-ripening in a large proportion of cherry plum seeds a lack of quantitative changes or even an accumulation of lipids was observed in contrast to the lowering of lipid levels at a temperature 3°C. A similar phenomenon was observed by Priestley and Leopold (1979) in conditions of accelerated ageing of soya seeds at a high temperature. Such changes were not observed in the endosperm or cotyledons of cherry plum, the dry weight of which constitutes 99% of the dry weight of the whole seed. In view of the small participation of embryo axes in the weight of the whole seeds Kawecki and Jaworski (1977) were not able to find changes in the lipids of whole cherry plum seeds stratified cold or in a warm-followed-by-cold thermal regime.

Lipids are being used up as the reserve material much more towards the end of the period of dormancy breaking in embryo axes than at the beginning. In seeds in which dormancy is not broken during stratification I was not able to observe any quantitative changes in the lipids of the embryo axes. It appears that in the warm phase of the warm-followed-by-cold stratification, at 20° or 25°C, the mobilisation of lipids is being withheld in the embryo axes of cherry plum seeds. This process may

have some connection with the unblocking of the dormancy mechanism and its latter overcoming at 3°C, though the studies of Villiers (1971) do not appear to confirm this hypothesis. That author observed a lowering in the level of lipids in the seeds of ash (*Fraxinus excelsior* L.) during the warm phase of a warm-followed-by--cold stratification. It needs to be mentioned however that in the seeds of that species during warm stratification there occurs an increase in the size of the embryo which was not fully grown before that. Probably in this process of embryo growth lipids were being used and later its dormancy is overcome only after action of low temperatures.

The second storage material besides lipids which occured in the seeds of cherry plum are sugars. In the warm phase of the warm-followed-by-cold stratification at 20°/3°C in the seeds of cherry plum reducing sugars are very rapidly used up in the embryo axes in contrast to the slow decline of their content at a temperature of 3°C (Fig. 3). After one week of stratification at 3°C it was observed in the cotyledons and endosperm that there is a much greater content of reducing sugars than at 20°C. Both at 3°C and at 20°C the direction of changes in the content sugars in the cotyledons and in the endosperm were similar. These results are in agreement with the observations of Wyzińska (1977) who had studied quantitative changes in reducing sugars during thermal induction of dormancy in the seeds of apple.

In the final stage of dormancy breaking in the seeds of cherry plum the lowering in the level of lipids in the embryo axes is accompanied by an increase in the level of reducing sugars. The content of lipids in the endosperm and cotyledons of seeds in which dormancy was being broken did not differ from that in the still dormant seeds, while in contrast, the level of reducing sugars underwent a clear lowering as dormancy was being broken.

The sugars were partially used up in the process of respiration and for the building of new cells in the embryo axes. This is indicated by the increase in the dry weight of embryo axes observed as stratification progresses. The increase in the dry weight of embryo axes is particularily great during the germination of cherry plum seeds even though Pollock and Olney (1959) have observed an increased increment in the dry embryo axes of the sour cherry variety Montmorency starting from the fourth week of stratification at 5°C. This is very noticeable at the time that there is a substantial decline in the dry weight of the endosperm of the germinating cherry plum seeds together with an increase in the dry weight of the cotyledons of these seeds (Table 1). This would suggest a displacement of such compounds as sugars from the endosperm to the cotyledons and to the embryo axes. One should particularily note the relatively large proportion of dry weight in the endosperm and a lower one in the cotyledons and especially in the embryo axes of seeds that were still dormant after 21 weeks of stratification compared to those in which dormancy is being broken (Tab. 1).

An increase in the level of reducing sugars was observed in the embryo axes of seeds which remained in stones with hardly visible cracks (about 0.05 mm wide) in the ventral suture. It appears that in fully imbibed seeds in the early phase of stratification there appear sugars in embryo axes which increase their osmotic poten-

tial and this as a consequence leads to the imbibition of still more water and finally the bursting of the stone shell along the ventral suture.

The results presented here on the respiration on the embryo axes and particularily of the respiratory quotient fully confirm the quantitative changes in the reducing sugars occurring during stratification of seeds at various thermal conditions.

Table 1

The percentage participation of embryo axes, endosperm and cotyledons in the dry weight of whole cherry plum seeds during the process of dormancy breaking in a warm-followed-by-cold--followed-by-warm-followed-by-cold stratification regime

Weeks of stratification 20°/3°/25°/3°C (2+2+2+30 weeks)	Physiological state of seeds	Percentage of total dry weight			Dry weight of 1 seed
		Embryo axes	Endosperm	Cotyledons	
		%	%	%	%
0	Intact stones	0.80	14.43	84.77	0.0955
9	Intact stones	0.83	14.74	84.44	0.0937
	Cracked stones	0.82	14.86	84.31	0.0930
21	Intact stones	0.72	16.08	83.19	0.0915
	Cracked stones	0.96	14.14	84.90	0.0944
	Germinated seeds (< 3 mm)	1.46	12.91	85.63	0.0945
36	Seedling (without light)	radicle 12.87 hypocotyl+ epicotyl 21.11	6.79	59.23	0.0866

During cold only stratification at 3°C which is not very effective in breaking dormancy in cherry plum seeds the respiratory quotient of the embryo axes did not change during the first 4 weeks of stratification which was parallel with the very slow drop in the level of reducing sugars.

Use of the thermal stimulus at 20°C preceding the stratification at 3°C has substantially improved the later capacity for seed germination. The rapid drop in the content of reducing sugars in the embryo axes after 1 week at 20°C is accompanied by a temporary increase in the respiratory quotient to 0.90. These sugars were therefore used up in the respiration process at that temperature after which their deficiency was manifested. As a consequence of the deficiency of simple compounds such as sugars, strongly hydrogenated compounds were to be utilized next, probably lipids (RQ=0.47 after 2 weeks). Possibly this pattern of changes had a decisive influence on the process of dormancy breaking in a fair proportion of the seeds.

Influence of the stratification temperature on the germinability of seeds needs to be considered in relation to its influence on the permeability of cytoplasmic membranes in the seed cells. In Fig. 4 it is shown that at a stratification temperature of 3°C the diffusion of substances from the endosperm and from the cotyledons into water was much greater than after stratification of seeds at a higher temperature (at 20° or 25°C). During the leaching of the electrolytes from cells the levels of ions, salts and others solutes are lowered irreversibly in the cytoplams (eg. ions of K, amino acids) as a result of which the physiological activity of cells is lowered (Ono and Murata 1981). According to Taylorson and Hendricks (1977) the integration of the structure

of the cytoplasmic membranes of organelles is, besides the integration of the associated metabolic system, one of the basic conditions for the overcoming of dormancy in seeds.

CONCLUSIONS

1. The basis storage material of cherry plum seeds are lipids. In the dry weight of the embryo axes of resting seeds they comprise 60%, in the cotyledons 52% and in the endosperm about 40%. The proportion of reducing sugars is 10%, 17% and 2% respectively.

2. During the breaking of dormancy in the seeds of cherry plum there occurs a transfer of reserve materials from the endosperm to the cotyledons and to the embryo axes. The increase in the dry weight of the embryo axes is greatest in the final stage of the after-ripening process. In the phase of germination (radicles less than 3 mm) the dry weight of the embryo axes increases by 82.5% relative to the embryo axes in dormant seeds. The increase in the dry weight of the embryo axes is accompanied at the same time by a decline by 10.5% of the dry weight of the endosperm and a 1% increase in the dry weight of the cotyledons.

3. Seeds that do not start germinating during stratification are characterized by a permanently lower dry weight of the embryo axes and cotyledons and a higher dry weight of the endosperm. The physiological state of these seeds is probably a reflection of the uneven spread of the state of seed maturity in the fruits starting from the time of flowering to the time of collection.

4. The most characteristic quantitative changes of the basic reserve materials (lipids and reducing sugars) in stratified seeds of cherry plum take place in the embryo axes. During cold only stratification at 3°C the content of lipids in the embryo axes gradually declines in contrast to the warm phase (20°C) of the warm-followed-by-cold stratification during which there occurs a slight increase in the content of lipids. Simultaneously at 3°C without any preceding warm stratification there occurs a slow gradual decline in the level of reducing sugars while at 20°C, the warm phase of the warm-followed-by-cold stratification, the decline is very rapid to a full disappearance. The reducing sugars reappear in the embryo axes during the cracking of stones.

5. In the warm phase of the stratification of cherry plum seeds the permeability of cell membranes declines compared to that in seeds stratified in the cold.

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LITERATURE

1. Amen R. D., 1968. A model of seed dormancy. Bot. Rev. 34: 1 - 31.
2. Bouvier-Durand M., Dawidowicz-Grzegorzewska A., Thévenot C., Côme D., 1984. Dormancy in apple embryos. Are starch and reserve protein changes related to dormancy breaking? Can. J. Bot. 62: 2308 - 2315.
3. Ermakov A., 1977. Masličnost' i žirnokislotnyj sostav masla semjan sortov slivy, alyči, terna i dr. (*Prunus* L.). Bjul. Vsesojuz. Ordena Lenina i Družby Narodov Inst. Rastieniev. im. N. I. Vavilova 73: 48 - 53.
4. Gassner G., 1938. Über die Harteschagligheit von Robiniensamen und eine Methode zu ihrer Beseitigung. Angew. Bot. 20: 293 - 303.

5. Hilditch T. P., 1951. Biosynthesis of unsaturated fatty acids in ripening seeds. Nature 167: 298 - 301.
6. Karssen C., 1982. The role of endogenous hormones during seed development and the onset of primary dormancy. In: Plant Growth Substances. Ed. Wareing P. F., 623 - 632.
7. Kates M., 1972. Techniques of lipidology: isolation, analysis and identification of lipids. Ed. Wash T. and Wash F., North Holland American, Elsevier.
8. Kawecki Z., Jaworski J., 1977. Fatty acids of raw fat triglycerides of stratified cherry plum (*Prunus cerasifera* var. *divaricata* Led.). Fruit Sci. Rep. 4 (2): 23 - 29.
9. Kawecki Z., Jaworski J., 1978. Tłuszczowce stratyfikowanych nasion ałyczy. Roczniki Nauk Rolniczych, Seria A, T. 103, Z. 3: 105 - 115.
10. Lewak S., Rychter A., Żarska-Maciejewska B., 1975. Metabolic aspects of embryonal dormancy in Apple seeds. Physiol. Vég. 13/1/: 13 - 22.
11. Mayer A., Shain Y., 1974. Control of seed germination. Ann. Rev. Plant Physiol. 25: 167 - 194.
12. Ono T., Murata N., 1981. Chilling Susceptibility of the Blue-green Alga *Anacystis nidulans*. II. Simulation of the passive permeability of cytoplasmic membrane at chilling. Plant Physiol. 67: 182 - 187.
13. Pollock B., Olney H., 1959. Studies on the rest period. I. Growth, translocation and respiratory changes in the embryonic organs of the after-ripening cherry seeds. Plant Physiol. 34: 131 - 142.
14. Priestley D., Leopold., 1979. Absence of Lipid Oxydation during Accelerated Ageing of Soybean Seeds. Plant Physiol. 63: 726 - 729.
15. Ryć M., Lewak S., 1982. Hormone Interactions in the Formation of the Photosyntethic Apparatus in Dormant and Stratified Apple Embryos. Z. Pflanzenphysiol. 107: 15 - 24.
16. Somogyi H., 1945. A new reagent for the determination of sugars. J. Biol. Chem. 160: 62 - 68.
17. Suszka B., 1962. Wpływ czynnika termicznego na ustępowanie spoczynku nasion dzikiej czereśni. Arboretum Kórnickie 7: 189 - 275.
18. Suszka B., 1967. Studia nad spoczynkiem i kiełkowaniem nasion różnych gatunków z rodzaju *Prunus* L. Arboretum Kórnickie 12: 221 - 282.
19. Taylorson R., Hendricks S., 1977. Dormancy in seeds. Ann. Rev. Plant Physiol. 28: 331 - 354.
20. Thévenot C., 1982. Correlations between axis and cotyledons in apple embryo dormancy. Z. Pflanzenphysiol. 106: 15 - 26.
21. Villiers T., 1971. Cytological studies in dormancy. I. Embryo maturation during dormancy in *Fraxinus excelsior*. New Phytol. 70: 751.
22. Wierszyłłowski J., Babilas W., Belec A., 1963. Niektóre zmiany zachodzące w nasionach ałyczy (*Prunus cerasifera* varietas *divaricata* Bailey) podczas ich strytyfikacji w stałej temperaturze 6°C. Pozn. Tow. Przyj. Nauk, Wydz. Roln. i Leśn., Prace Komisji Nauk Leśn. 14(3): 229 - 244.
23. Wyzińska D., 1977. Wtórny spoczynek nasion jabłoni. Doctoral thesis.

Uwarunkowania przebiegu ustępowania spoczynku nasion ałyczy (Prunus cerasifera var. *divaricata* Bailey). I. *Zmiany ilościowe materiałów zapasowych podczas ustępowania spoczynku nasion w zróżnicowanych warunkach cieplnych*

Streszczenie

Badano zmiany ilościowe lipidów i cukrów redukujących w osiach zarodkowych, bielmie i liścieniach nasion ałyczy stratyfikowanych w trzech różnych układach cieplnych. W tych samych układach stratyfikacyjnych badano pobieranie tlenu przez izolowane z nasion osie zarodko-

we oraz wpływ tych warunków na przepuszczalność błon cytoplazmatycznych komórek stratyfikowanych nasion.

Stwierdzono, że podczas stratyfikacji nasion w 3°C (niska zdolność kiełkowania) zawartość lipidów i cukrów redukujących w osiach zarodkowych obniża się powoli i stopniowo, natomiast podczas ciepłej fazy stratyfikacji ciepło-chłodnej 20°/3°C (wysoka zdolność kiełkowania) zawartość cukrów redukujących obniża się gwałtownie aż do zaniku (cukry te są zużywane w procesie oddychania), a zawartość lipidów w tej temperaturze nieco wzrasta. W ciepłej fazie stratyfikacji przepuszczalność błon cytoplazmatycznych jest mniejsza niż podczas stratyfikacji nasion w chłodzie.

ТАДЕУШ ТЫЛЬКОВСКИ

Обусловленность течения уступания состояния покоя семян алычи (*Prunus cerasifera* var. *divaricata* Bailey). I. *Количественные изменения запасных веществ в период уступания состояния покоя семян в различном термическом режиме*

Резюме

Исследовали количественные изменения жиров и редуцирующих сахаров в зародышевых осях, эндосперме и семядолях семян алычи, стратифицированных при трех различных тепловых режимах. В тех же условиях стратификации исследовали поглощение кислорода изолированными из семян зародышевыми осями, а также влияние этих условий на проницаемость цитоплазматических мембран клеток стратифицируемых семян.

Найдено, что в период стратификации семян при 3°C (низкая способность прорастания) содержание жиров и редуцирующих сахаров в зародышевый осях медленно и постепенно понижается, тогда как во время теплой фазы стратификации тепло-холодной 20°/3°C (значительная способность прорастания) содержание редуцирующих сахаров уменьшается резко вплоть до полного исчезновения (эти сахара расходуются в процессе дыхания), а содержание жиров при этой температуре немного возрастает. В теплой фазе стратификации проницаемость цитоплазматических мембран меньшая нежели во время холодной стратификации.