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Contribution to the discussion: Are the embryos of the apple tree cv. Antonovka in a strate of dormancy? and an answer to Lewak's critical note on the paper of Czerski and Jankowska*

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The appearance in Acta Soc. Bot. Pol. the critical note by Lewak (1979) referring to the paper of Czerski and Jankowska (1977) of this Department entitled: "Growth of the apple tree *(Malus Domestica)* Borkh cv. Antonovka obtained from non-stratified seeds "obliged us to express our opinion in the form of discussing article on the subject mentioned in the title of this note.

The objective of the article is to analyse and discuss the crucial points of the statement of the Lewak's group research problem, methodical approach, results and their interpretation, and confront them with the results obtained in this Department and the literature data, and to answer to Lewak's critical note on the paper of Czerski and Jankowska (1977).

Seed dormancy is crucially important for plant life and numerous mechanisms have evolved to achieve this stage of plant survival, a period of extremely reduced metabolic activity, low content of water, lack of growth, during which the seeds pass through unfavourable conditions of winter cold or drought of arid summer. This aspect of plant life has been presented extensively in texts and review articles (for instance: Toole et al. 1956; Crocker and Burton 1957; Mayer and Poljakoff-Meyber 1963; Vegis 1964; Burton 1965; Grzesiuk 1967; Lityński 1977; Khan 1977).

Amen (1968) considered seed dormancy as an aspect of growth cessation and restricted the term of "dormancy" to an exogenously

* According to the recommendation of the Editor-in-Chief of the Journal to limit and close the discussion on this subject, the authors combined two separate articles previously submitted for publication into the one presented below.

controlled evironmentally imposed temporary suspension of growth, accompanied by reduced metabolic activity and relatively independent of ambient environmental conditions".

Many species of plants particularly woody species have evolved an additional mechanism which prevents seed from germination immediately after sowing, even when other environmental conditions are favourable. The further period of development after seeds are sown and before they can germinate is called "after ripening".

The whole seed of apple requires 2 to 5 months chilling period in moist environment at the temperature optimum 4—5°C for after--ripening period. This is called "stratification" during which seeds germinate. The germination of seeds as well as an isolated embryos during stratification of apple has been recently observed by Thevenot and Come (1973) and Thevenot et al. (1977).

It is well known that many factors cause seed dormancy by preventing germination:

1. an environmental factors — light requirement (positive or negative), absence of water, high temperature;

2. internal factors — seed coat preventing gas exchange or mechanical effect, embryo immaturity, low ethylene concentration, presence of inhibitors, absence of growth promotors;

3. timing mechanism — after ripening, disappearance of inhibitors, synthesis of growth promotors.

The majority of the Lewak's group investigation concern germination in light (12 hours photoperiod) of isolated embryos of apple cv. Antonovka. It means that an embryo lacks covering structures eg. coat and endosperm. Therefore, such factors of dormancy as negative light requirement, prevention of gas exchange, presence in these structures inhibitors, lack of water are absent.

For such isolated embryos a precise term of dormancy has been defined by Vegis (1964) "truly dormant seed embryos cannot, by any means, be induced to normal immediate growth. Upon termination of the true dormancy state, the phase of main rest passes on to the final phase of rest period which is called: period of after-ripening for seeds" (p. 188).

Recently a representative review of all results and their interpretations concerning this subject has appeared (Lewak and Rudnicki 1977). They pointed out: "Embryos excised from dormant apple seeds, unlike most others are able to germinate very slowly at room temperature. This makes them a convenient material for studying the effects of various factors on dormancy. The above considerations and our continuous involvement with apple seeds prompted us to examine in detail the problem of dormancy of these seeds" p. 194.

As a criterion of dormancy they mention: "even after 2 weeks of culture the per cent of germinated dormant embryos does not exceed 30%". Therefore in studying the influence of exogenous factors on embryonal dormancy, their effect on the number of germinating embryos should be considered first of all" p. 209. and ... "Dormant embryos from apple and other cold-requiring seeds, if germinated grow abnormally ... and those which germinate are not able to continue growth, have a tendency to be dwarf, have abnormally developed internodes and often form rosette-type plants (Flemion 1931, 1934; Barton 1944). All of the abnormalities of embryo germination and seedling growth attributable to embryonal dormancy can be overcome only by an appropriate period of chilling" p. 195.

They also showed the photosensitivity of apple embryos (Lewak and Smoleńska 1968) and in the mentioned review pointed out: "The action spectrum of this photosensitivity and the reversibility of red-far red light effects prove the involvement of phytochrome in light-dependent stimulation of apple embryo and seed germination" p. 208. These quotations make clear their research problem, the criteria of dormancy, as well as an important feature of embryos the photosentitivity (positive photoblastonic embryos).

METHODICAL APPROACH

In studies of metioned group as long as 14 years of experimentation they based only on the examination of germinability according to first criterion of dormancy mentioned above.

Unfortunately they never examined the validity of the second criterion that is inability of seedlings originating from non-stratified embryos to grow.

They used the apple seeds cv. Antonovka obtained from the Experimental Stations of the Institute of Pomology. Seeds were imbided 24 hours in water, covering structures the seed coat and endosperm were removed and the naked embryos were placed on Petri dishes (usually 100 embryos on 3 dishes). After addition of water, the dishes were transferred to a growth chamber and illuminated during 12 hours daily with 10^4 lux light from fluorescent tubes at 25°C during the day and 20°C during the night. The percent of germinated embryos either stratified or non-stratified was established during an arbitrary 10 days of culture which means that they determinated the "energy of germination". Such an arbitrary period for examination of germination of apple embryos is a matter of controversy, because for seeds of fruit trees the appropriate period for examination of germinability i.e. "germination power" is 42 days (Methods of seeds estimation, Warszawa 1926). This subject will be discussed further.

RESULTS AND MISTAKES

The first controversial data obtained in studies of this group concern the superisingly low percentage of germinating isolated embryos from non-stratified seeds, entirely different from those observed in this Department (Czerski and Jankowska 1977). It must be stressed here that Czerski and Jankowska used essentially the same procedure for examination of germination as that applied by Lewak's group. After 10 days of culture Czerski and Jankowska noted the following percentage of germinated embryos isolated from non-stratified seeds: 85,0, 59,6, 71,1 and 60,2 in the 1971, 1975, 1976 and 1977 experiments respectively. These values were comparable to those for stratified seeds. It should be stressed here that Czerski and Jankowska examined as many as 300 embryos in each experiment as compared with only 100 embryos in the Lewak's group studies.

Table 1 presents some collected data on the germinability of non-stratified embryos of the apple cv. Antonovka obtained by Lewak and coworkers. A comment to this table will be given further.

Table 1

Germination of non-stratified isolated embryos of apple cv. Antonovka after 10 days of culture

%	References
50	Smoleńska and Lewak (1974)
28	Lewak et al. (1975)
23	Bogatek et al. (1976)
9 *	Wyzińska and Lewak (1978)

* after 9 days of culture.

Therefore, the statement of Lewak and Rudnicki (1977) that the germination of non-stratified embryos of apple does not exceed 30 per cent even after 2 weeks of culture is not true!

Anyone who has applied the described procedure for examination of germination can readily obtain within 2—3 weeks of culture a high percentage of germinating embryos and test that this statement is meaningless. Moreover, if one accept the reality of the data presented in table 1 50 per cent of germination of isolated embryos should be taken as a warning signal that embryos were not dormant, since the prolongation of observations of germination for instance to 2 or 3 weeks will produce high percentages of germinating embryos.

It is hard to understand why, in further studies shown in table 1, non-stratified embryos of apple of the same cultivar germinated so badly. On the other hand, further explanation to these data is ne-

cessary: how can such a diversity in the germinability of embryos be considered as a "model" research on dormancy?

As early as (1963) Duczmal and Duczmalova published data on the germinability of isolated embryos of the apple cv. Antonovka. Using a different procedure for examination than the above mentioned group they showed the same percentage of germinated isolated embryos derived from non-stratified seeds as compared with the germination of 18 weeks stratified seeds examined at 4°C and 20/24°C.

These authors also showed the decisive inhibitory role of endosperm in germination of non-stratified embryos of the apple cv. Antonovka. It should be mentioned here that as early as 1953 Büning indicated that the endosperm is the site of inhibitory factors of germination of apple seeds.

Recently in this Department we also noticed the inhibitory effect of endosperm on germination of apple seeds (unpublished data).

The further decisive mistake in the studies under discussion concern the comparison of non-comparable embryos, that is those, which were not stratified with those after stratification. As mentioned above during stratification embryos germinate. Thevenot and Come (1973) for example noticed practically 100% of germinated embryos of apple after 88 days of treatment at a stratification temperature of 5°C. This is even documented by Sińska and Lewak's observation when they mention for the 90 days stratified embryos of the apple cv. Landsberger Reinette $\Sigma_{10} = 993$, this meaning that after 1 day of culture practically all tested embryos already germinated.

Recently Lewak and Dawidowicz-Grzegorzewska (1977) carried out an experiments to support their "model" of apple embryo dormancy. They simply noticed changes in the anatomical structures of stratified embryos and a lack of such changes in embryos isolated from non-stratified seeds of apple after as litle as 12 hours of imbibition in water. What could they expect?

Our recent data (unpublished) indicate that the changes in the anatomical structure of non-stratified embryo already after 3 days of germination are comparable to those observed by Dawidowicz-Gorzegorzewska and Lewak (1977) after 90 days of stratification. This finding presents additional evidence that the germinated in light non-stratified embryo of the apple cv. Antonovka is ready for immediate growth without a period of chilling. Sińska and Lewak (1974) pointed out that the state of dormancy of the embryo is completed after 18 days drying of the seed removed from the fruit. In this aspect of the discussion it is worth to mentioning that germination is the "bringing of the embryonic axis into a state of continual growth" and is "the transformation of an embryo into a seedling" as defined by Jann and Amen (1977).

A false arguments of the author of "the critical note on the paper of Czerski and Jankowska"

In his first remark the author of "the critical note" is not satisfied that the paper of the mentioned authors, according to his opinion does not "substantially contribute to solve the problem of embryonal dormancy".

From the results presented by Czerski and Jankowska (1977) as well as the analysis of the results of the studies of Lewak's group it is clear that there was nothing to solve, since under the conditions of the experimentation described above such a phenomenon as a truly dormant embryo isolated from non-stratified seeds of the apple cv. Antonovka simply does not exist! This conclusion is a logical consequence of the precise definition of embryonal dormancy of Vegis (1964) quoted above. At this point of discussion it should be stressed here that in their publications they often quoted the review article of Vegis (1964) concerning the problem of dormancy in higher plants, but surprisingly, they never quoted or discussed his definition of embryonal dormancy! Therefore one can ask: what was the true criterion for determination of the state of "embryonal dormancy" of apple according to the applied procedure?

It was a determination of what is called "energy of germination" after 10 days of culture. There is however a crucial point: the term of "energy of germination" in the sense of the ISTA recommendation does not exist (Lityński 1977) p. 103). This author indicates that determination of "energy of germination" has a little value because it does not fulfill the main task of germinability estimation that is further normal growth of seedlings. Lityński (1977) also indicates that the appropriate examination of seeds germination means the determination of the number of seeds which in favourable conditions are capable of germination thus "germinability" or "power of germination".

The conditions for germinability estimation are different for various species of plants and for instance for apple trees the period of 42 days is recommended (Methods of seeds estimation 1926). The second remark of the author of "the critical note" concerns the indication: "There are two ways of proper experimentation: 1 — to investigate the germinability at a wide temperature range (Vegis, 1964), or 2 — to investigate the dynamic of germination (Thevenot and Come, 1973)".

It should be made clear here that these objections should be addressed not to Czerski and Jankowska's study, but to the investigations of the mentioned group, because as shown above they never applied indicated 2 ways of proper investigation. The reader, therefore is surprised when he reads in "the critical note": "The

authors of the paper under discussion performed the investigation of germination of embryos isolated from stratified and dormant apple seeds simply by counting the germinated embryos after arbitrary chosen 10 day period of culture". As a matter of fact an arbitrary 10 days culture for testing germinability has been chosen by the mentioned group throughout the course of their studies!

It must be put clearly here that the objective of Czerski and Jankowska's study (1977) was to investigate whether embryos isolated from non-stratified seeds of apple, treated according to procedure described, possess features of truly dormant embryos. Moreover, Czerski and Jankowska also tested in their study the second criterion of true dormancy of apple, that is the inability of growth of seedlings originating from non-stratified embryos of apple, the criterion which has not been examined in studies of mentioned group. The next "arguments" against the results presented by Czerski and Jankowska (1977) came from the quotations of data from the literature, which according to the author of "the critical note" should support the results of studies of his group. The data from his own Laboratory in the light of the discussion presented above are meaningless.

There remain therefore, to be considered the experimental data of the germination of non-stratified isolated embryos of the apple cv. Antonovka of other authors quoted by Lewak: Nikolaeva's and Jankielewitch's (1976) from Leningrad and Thevenot et al. (1977) from Come's Laboratory in Paris. The reader of the mentioned paper of Nikolaeva and Jankielevitch (1976) however, is faced with the fact that these authors examined germination of isolated embryos in darkness but not in a 12 hour photoperiod as in the mentioned group studies.

Moreover, they used embryos after 5 days of imbibition of seeds in water and counted germinated embryos 4 days after isolation. Most surprising, however, is a quotation of the study carried out in Paris!

The paper of Thevenot, Gaspar, Lewak and Come (1977) concerning the germination of isolated embryos of cv. Antonovka in darkness either at 5 or 20°C during a period as long as 45 days. Is it possible that the author of "the critical note" forgot about the procedure he had applied in the study of which he is coauthor? It must also be noted here that the above quoted paper of Thevenot and Come (1973) which is indicated as a correct way of experimentation evaluates also germination of isolated embryos of apple in darkness. Neither is the procedure for germination applied by Kamiński and Pieniążek (1968) comparable with that applied by the mentioned group. Therefore, it is evident that Czerski and Jankowska were right when they pointed out: "the differences could have been

caused by different germination conditions" and contrary to the Author's "critical note" quotations, they were entirely entitled to deny occurrence of dormancy of apple embryos in Lewak's group studies. These examples of the author of "the critical note" approach in the discussion are illustrative, since they present an evidence that he used arguments either not true or awry!

As mentioned in the introduction, embryos of apple isolated from non-stratified seeds are photosensitive. They are positive photoblastonic that is light is a necessary exogenous factor for induction of germination, similar to water or appropriate temperature.

Light as a factor in germination has been the subject of a recent and representative review (W i d a v e r 1977). Therefore, it must be stated that isolated embryos of the apple cv. Antonovka if germinated in favourable conditions eg. in the presence of water, appropriate temperature and illumination they are ready without chilling for growth and after 3—4 weeks of culture almost 100% of the embryos will germinate. How can they be considered as dormant?

The last argument of the author of "the critical note" concerns the second criterion of dormancy the inability to growth of seedlings derived from non-stratified apple seed embryos. In his "critical note" he pointed out: "dwarfism has never been taken as a criterion of dormancy". The reader of such a statement is astonished when he compares the statement concerning this subject in L e w a k and R u d n i c k i's review article (1977) see introduction to present article).

From their consideration of dwarfism as a criterion of embryonal dormancy and from their statement in this review article it is evident that they accepted without comment the inability to grow of seedlings originating from non-stratified apple seed embryos.

This is also documented in their numerous publications for example (S i ń s k a and L e w a k, 1970; S m o l e ń s k a and L e w a k, 1974; L e w a k et al., 1975; W y z i ń s k a and L e w a k, 1978). It is evident that his "argument" against the paper of C z e r s k i and J a n k o w s k a (1977) misses the mark and provides an additional example of the unfair attitude of the author of "the critical note" in the present discussion. Unfortunately, in the mentioned group studies lack experimental data concerning the growth of seedlings originating from non-stratified embroys of apple, therefore there are no grounds to discuss further this criterion.

Some other aspects of their results, particularly concerning the development of the photosynthetic apparatus of seedlings, are currently under study in our Department and will be discussed in future publications.

On the basis of the above discussion presented one can conclude:

1. An isolated embryo from non-stratified seed of the apple cv. Antonovka if illuminated, incubated in the presence of water at appropriate temperature is ready for immediate growth. This can be easily tested in the course of studies on germination. An immediate growth of non-stratified embryos under favourable conditions can be also seen in the course of examination of changes in the anatomical structure of the embryo during germination. Moreover, the seedlings originating from non-stratified apple seed embryos cv. Antonovka are entirely comparable to those derived from stratified ones (Czerski and Jankowska 1977). The role of stratification in breaking dormancy of the seed as a whole of the apple cv. Antonovka is due to physiological abolition of same inhibitory factors mainly in the endosperm.

2. It is documented that under the statement of the research problem and methods applied by Lewak's group, they failed to study "true embryonal dormancy".

3. An analysis of Lewak approach to discussion expressed in his "critical note" illustrates that he had used an arguments either unfair or awry.

4. The authors of this article are convinced that the present discusion will be helpful for planning of research problems and experiments in further studies on dormancy of apple seeds.

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Wkład do dyskusji: „Czy zarodki jabłoni odm. Antonówka są spoczynkowe?" i odpowiedź na krytyczną notę Lewaka w stosunku do pracy Czerskiego i Jankowskiej

Streszczenie

W przedstawionym artykule zawarto krytyczną analizę ustawienia problemu badawczego, tj. „spoczynku zarodkowego nasion jabłoni" odm. 'Antonówka', stosowanych metod, wyników i ich interpretacji w pracach Lewaka i współpracowników oraz odpowiedź na „krytyczną notę" Lewaka (1979) w stosunku do pracy Czerskiego i Jankowskiej (1977).

W konfrontacji z danymi uzyskanymi w Zakładzie Metabolizmu Roślin Instytutu Botaniki UW, danymi z literatury i bieżącymi pracami Zakładu na ten temat wykazano, że:

1. Wieloletnie badania Lewaka i współpracowników są niezgodne z naszymi obserwacjami,

2. treść wspomnianej „krytycznej noty" wskazuje, że jej autor prezentuje niewłaściwe stanowisko w badaniach naukowych. Wymienione wnioski są potwierdzone przez następujące dowody:

Ad. 1. Wieloletnie obserwacje kiełkowania niestratyfikowanych zarodków jabłoni odm. 'Antonówka' prowadzone przez Czerskiego i Jankowską (1977), jak również bieżące badania w Zakładzie wykazują wysoki procent kiełkowania tych zarodków. Dowodzą one, że publikowane przez Lewaka i współpracowników dane o bardzo słabym kiełkowaniu takich zarodków są nieuzasadnione. Każdy, kto zastosuje opisaną przez Lewaka i współpracowników procedurę do oceny kiełkowania, tj.: z namoczonych w ciągu 24 godz. w wodzie niestratyfikowanych nasion jabłoni wym. odmiany, usunie okrywę nasienną i bielmo (wykształcone w nasionach jabłoni w postaci delikatnej błonki), ułoży po 30 zarodków na wyłożonej bibułą filtracyjną szalce Petriego, doda kilka ml wody, szalki z zarodkami ustawi pod oświetleniem jarzeniowym przy 12 lub 16-godzinnym fotoperiodzie, to stwierdzi po 2—3 tygodniach bardzo wysoki procent skiełkowanych i rosnących zarodków. Jeżeli dodatkowo na szalkach ułoży:

a) zarodki z bielmem, to stwierdzi znikomy procent kiełkowania spowodowany obecnością w bielmie czynników hamujących kiełkowanie,

b) przeprowadzi 90-dniową stratyfikację nasion jabłoni w temperaturze 4—5°C, zgodnie ze znaną metodą dla nasion jabłoni, to, przekona się, że znaczna część nasion po wymienionym czasie skiełkuje i będzie miała widoczne kilkucentymetrowe korzonki.

Proste te doświadczenia dowodzą, że dodatnio fotoblastyczne zarodki jabłoni odm. 'Antonówka', nie spełniają zasadniczych kryteriów zarodków spoczynkowych, tj. takich, które nie kiełkują w sprzyjających warunkach a pośród tych, które skiełkowały ich siewki nie będą zdolne do wzrostu, tj. pozostaną karłowate.

Usunięcie bielma z zawartymi w nim czynnikami, hamującymi kiełkowanie zarodka, powoduje jego bezpośredni i normalny wzrost i rozwój, a wyrosła siewka jest całkowicie porównywalna z pochodzącą z zarodka stratyfikowanego. W przebiegu chłodnej stratyfikacji całego nasienia natomiast ma miejsce powolne fizjologiczne usuwanie czynników inhibujących, zawartych głównie w bielmie, i powolne kiełkowanie zarodków w tych warunkach. Dla każdego, kto przeprowadzi wymienione proste doświadczenia, stanie się oczywista bezzasadność „problemu spoczynku zarodkowego" oraz „modelu" tego spoczynku u nasion jabłoni odm. 'Antonówka'.

Ad. 2. Autor krytycznej noty w stosunku do pracy Czerskiego i Jankowskiej (1977) wyraża:

a) niezadowolenie z tego, że praca Czerskiego i Jankowskiej nie wnosi „istotnego wkładu" do rozwiązania problemu „spoczynku zarodkowego" nasion jabłoni. Odpowiedzią na ten zarzut jest stwierdzenie, że nie można wnieść wkładu w wyjaśnienie zjawiska, które nie istnieje! Zdaniem naszym praca wniosła wkład zasadniczy, wykazując brak zjawiska, którego występowanie w tak wielu pracach Lewak i współpracownicy usiłowali udowadniać i badać;

b) przypisuje Czerskiemu i Jankowskiej (1977) wybranie dla oceny kiełkowania arbitralnego okresu, tj. 10-dniowej hodowli. Jest to zarzut zaskakujący, ponieważ w ogromnej większości prac grupa Lewaka stosowała właśnie przez nich wybrany arbitralnie 10-dniowy okres hodowli zarodków. Oznaczali Oni zatem tzw. „energię kiełkowania". W rozumieniu przepisów ISTA termin „energia kiełkowania" właściwie nie istnieje (Lityński, 1977). Przypisywanie Czerskiemu i Jankowskiej tego zarzutu świadczy o tym, że był On świadom błędności stosowanej metodyki oceny kiełkowania w badaniach kierowanej przez Niego grupy. Stosowne jest przypomnienie, że nawet oznaczanie kiełkowania wymienionych zarodków w ciągu 10 dni wyjawia brak spoczynku zarodkowego.

c) Autor wspomnianej noty cytuje pozycje literatury, które Jego zdaniem winny potwierdzać wyniki badań Jego i współpracowników. Wskazuje na 2 właściwe sposoby prowadzenia doświadczeń:

1. badanie zdolności do kiełkowania w szerokim zakresie temperatur wg Vegis'a (1964),

2. badanie dynamiki kiełkowania wg Thevenot i Come'a (1973).

Zarzut ten, jak i poprzedni stanowi wprowadzanie w błąd czytelnika, ponieważ w pracach grupy Lewaka nigdy nie stosowano wskazywanych przez Niego właściwych sposobów eksperymentowania, oznaczając jak wspomniano wyżej jedynie „energię kiełkowania". We wspomnianych pracach Come'a kiełkowanie zarodków jabłoni odbywało się w ciemności, natomiast w pracowni Lewaka kiełkowano je w 12-godzinnym fotoperiodzie. Lewak w swej nocie powołuje się nawet na pracę z pracowni Come'a w Paryżu, w której występuje jako współautor (Thevenot i współprac. 1977), z której wynika, że niestratyfikowane zarodki jabłoni odm. 'Antonówka' kiełkowały w ciemności w ciągu 45 dni! Co więcej, Lewak i współpracownicy (Smoleńska i Lewak 1968) wykazali, że zarodki jabłoni wym. odmiany są dodatnio fotoblastyczne, co oznacza, że światło stanowi dla nich czynnik, tak samo niezbędny do kiełkowania i wzrostu, jak dostarczenie wody, powietrza i zapewnienie odpowiedniej temperatury. Wprowadza w błąd również cytowana praca Nikołajevej i Jankielewicza (1976) z Instytutu Botaniki AN ZSRR w Leningradzie. Wymienieni autorzy z niezrozumiałych powodów moczyli nasiona jabłoni odm. 'Antonówka' 5 dni w wodzie, po czym, po usunięciu struktur okrywających, izolowane zarodki kiełkowały w ciągu 4 dni w ciemności!

d) W krytycznej nocie Lewak stwierdza: „karłowatość nigdy nie była przyjmowana jako kryterium spoczynku". Konfrontacja tego zaskakującego stwierdzenia z wieloma pracami Autora „noty" i współpracowników, przykładowo: Sińska i Lewak (1970), Smoleńska i Lewak (1974), Lewak i wsp. (1975), Wyzińska i Lewak (1978), jak również artykuł przeglądowy Lewaka i Rudnickiego (1977), wykazują nieprawdziwość tego stwierdzenia. Należy zaznaczyć, że wymieniona grupa wszakże nigdy nie wykonała doświadczeń stwierdzających prawdziwość tego kryterium w stosunku do siewek jabłoni odmiany 'Antonówka'.