# MEASUREMENT OF POTATO TUBERS RESISTANCE TO MECHANICAL DAMAGE

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With the increasing mechanisation of harvest and further treatment of potatoes most operations are performed with high-yield machines, and it is the reason of the increased number of tubers mechanical damages. According to Larsen [3], damages during harvest and sorting amount to 54%, and transport with loading increase this number by about 10%. Specht [6] has evaluated tubers damages at harvest to about 15—75%. With such a high damage proportion it was necessery to find out new realizations of machines structural components which directly cause tuber damage as well as more accurate methods of measurement of the tubers resistance.

Evaluation of mechanical damage of tubers just after the harvest are usually made by measuring the depth of flesh injury. The tubers were placed in four categories: I — undamaged, II — slightly damaged 0-1.7 mm of depth, III — moderately damaged 1.7-5 mm of depth, and IV — severely damaged $\geqslant 5$ mm. The weight of each group (expressed in %) multipled by appropriate factor "K"; K = 0.1 for slightly damaged, K = = 0.3 for moderate damage and K = 1 for severe damage gives the general damage index "W". This general index is accepted by all countries of the Council for Mutual Economic Aid. "Damage index" [5] is used on a similar basis in other countries. It comprises surface abrasion, damage at a depth below 2 mm and damage at a depth above 2 mm and appropriate factors equaling 1, 3, 7 respectively. The sum of all three products is a damage index.

Damage assessment is facilitated by immersing tubers in an aqueous solution of Catechol. Broken tissue shows red after such treatment. Basing this on the method mentioned above one can evaluate real damage arising during harvest and further treatment. All methods of this kind are very laborious so attempts are made to assess tubers with static and dynamic laboratory methods.

The most frequently used laboratory static apparatus is Lampe apparatus [2]. A plunger 3.5 in diameter, is pressed into an immobilized tuber with loading increasing until the plunger breaks periderm. Then the plunger loading is recorded. The value of the loading, expressed usually in arbitrary units is a measure of tuber resistance. There are a variety of Lampe-type apparatus, differing in a method of load value recording when the periderm is broken. Other static apparatus is proposed by Meinl [4]. It is used to determine tuber ability to radial compression. The potato tuber is radially compressed in the smallest dimension during 15 sec with a loading of 1 kG. Results expressed in milimeters gives a "degree of deflectibility".

According to numerous authors, tuber resistance against damage depends on its flexibility. Flexibility is measured as energy not absorbed by tuber impacted with a known mass. The most frequently used apparatus for determining tuber flexibility is a Gall pendulous apparatus [1]. A weight fixed on a pendulum arm measures the impact of an immobilized tuber. Angular displacement of the pendulum is recorded.

In Gross-Lüsewitz apparatus PSW-70 is used. The pendulum of the PSW-70 will impact a tuber twice: if angular displacement of the second impact is equal to or greater than that of the first impact the tuber is assessed as undamaged (elastic). In other cases the tuber is assessed to be damaged i.e. of smaller elasticity.

The apparatus worthy of notice is one, proposed by Meinl [4]. It is used to determine the "reflection-rotation component". Tubers of equalized mass are dropped from 1 m on a concrete block with a thumb-tack attached to a thread on it. When dropped the tuber bounces to a height, drawing a thread with it. The length of the thread drawn is a measure of the "reflection-rotation component" (flexibility).

In the Independent Preservation Laboratory of Patotoes Research Institute in Jadwisin tuber susceptibility to damage was investigated with the most popular Gall- and Lampe apparatus. Results obtained were compared with damage index "W". Following factors were taken into consideration:

1) variety Uran and Flisak,
2) haulm destruction with Reglone,
   — early haulm destruction during full vegetation when the majority tubers were of seed-potatoes size,
   — late haulm destruction in full technical maturity.
3) time of harvest,
   — in 14, 21 and 28 days after early haulm destruction,
   — in 7, 14 and 21 days after late haulm destruction.

4) method of harvest,
   — potato elevator-digger,
   — combine-harvester.

After each harvest mechanical damage arising during potatoe lifting was evaluated on 6 groups, 10 kg each and it was characterised by damage index "W". At the same time tuber resistance was determined with a dynamic penetrometer and static penetrometer on 50 tubers. The penetrometers were produced by IMER (actually IMBER), Warsaw.

The aim of our 3-years studies was to find a correlation betwen real damage during harvest and tuber restistance evaluated with the penetrometers. In studies discussed satisfactory correlation was not found between damage during harvest and reading of penetrometers. Worthy of notice is the high correlation coefficient for static and dynamic penetrometers ($r = +0.7$). It can be concluded that tuber resistance evaluated by pressing a plunger ($\phi = 3.5$ mm) shows similar characteristics as methods in which the amount of energy not absorbed by a tuber impacted with a pendulum arm with a spherical end-piece is determined.

Diagram 1 shows real damages during harvest expressed with a "W" index in dependence on the time of haulm destruction and the time of harvest in comparison with the penetrometers reading. Larger tuber da-

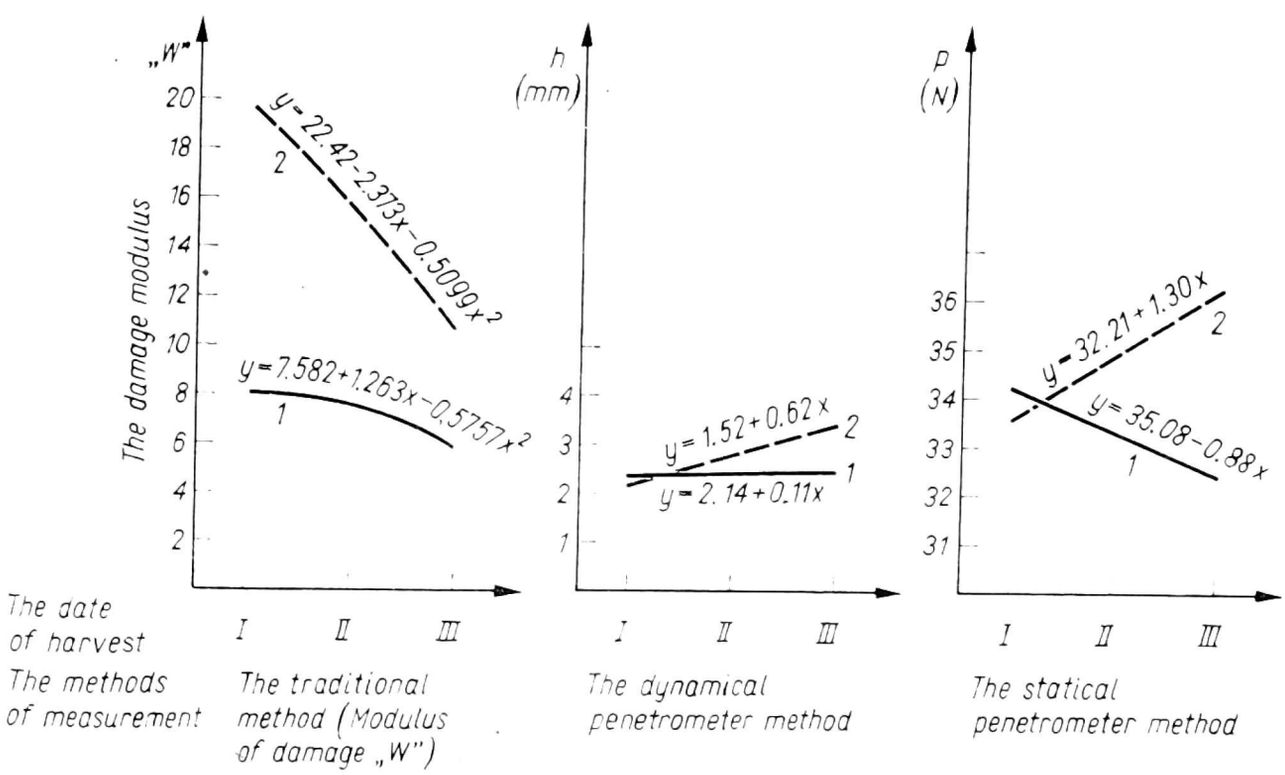


Fig. 1. Degree of tuber damage as effect of time of haulm destruction and lifting. The comparison of three methods of damage estimation. *1* — Early time of the haulm destruction, *2* — Late time of the haulm destruction (after maturity)

mage was shown at harvest after late haulm destruction (during full technical maturity) as compared with tuber damage harvested after early haulm destruction. This can be explained by large air and soil temperature variations and to a smaller degree, by the physiological status of tubers. However a delay of potatoes lifting after haulm destruction (III time limit) causes a decrease in the damage index "W", so the number of damaged tubers decreases. Penetrometers readings at 3 harvest time limited after late haulm destruction have a tendency to increase and it is in accordance with the decreased real damage. With early haulm destruction this effect is opposite.

Having analyzed damages caused by lifting machines (diagram 2) one can state larger damage during harvest with a combine-harvester as compared with a potato elevator-digger. It is in agreement with the results of investigations of several other authors. The damage index "W" clearly decreases at the third time limit of harvest. It is especially seen during a combine-harvest. Penetrometer readings confirm this effect as they increase at the time, which illustrates larger tuber resistance against mechanical damage. Numerous investigations have shown, that tuber susceptibility to mechanical damage is specific for each variety. Investigations performed on varieties Uran and Flisak (diagram 3) have shown higher susceptibility of the first variety. It is concerned with an early harvest after haulm destruction both during full vegetation and during

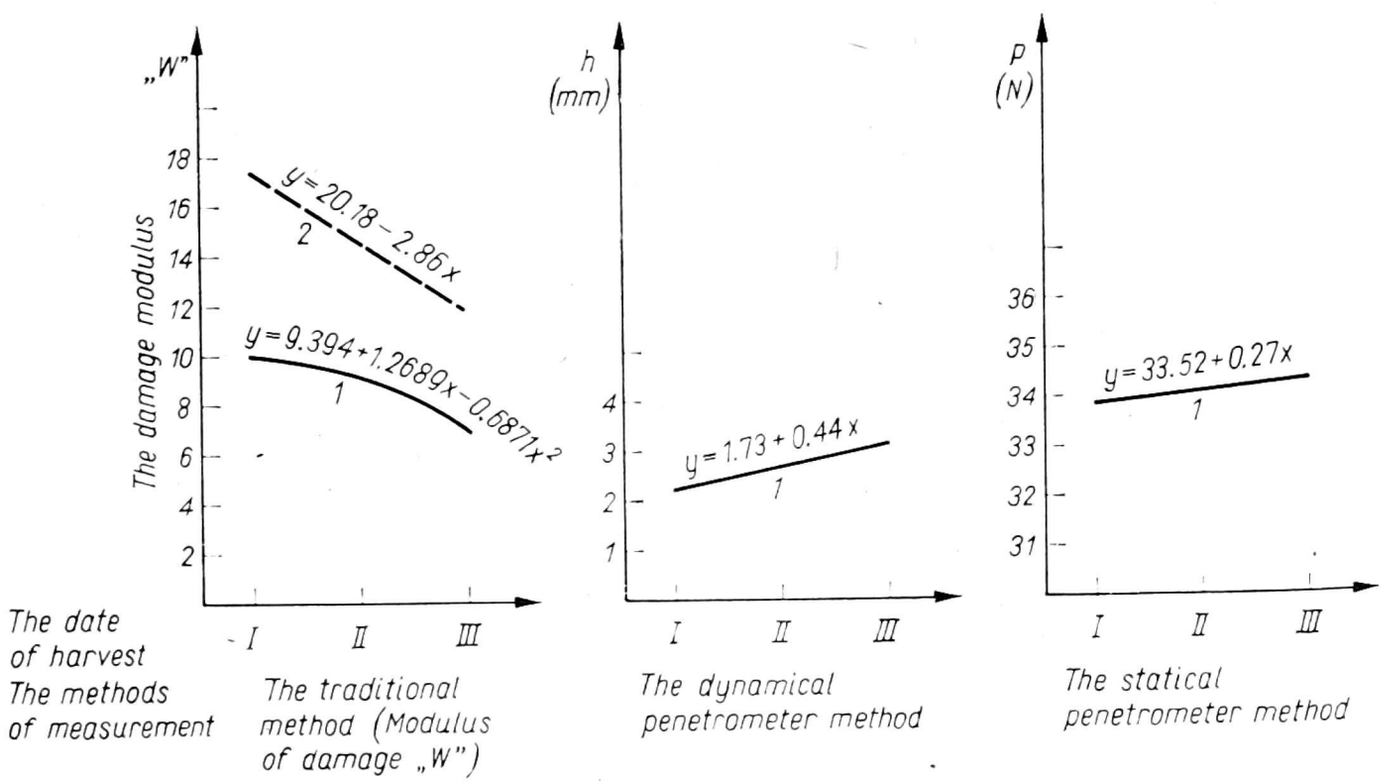


**Fig. 2.** The effect of time harvest and methods of lifting on the tuber damage. The comparison of three methods of damage estimation. *1* — elevator digger, *2* — potato harvester

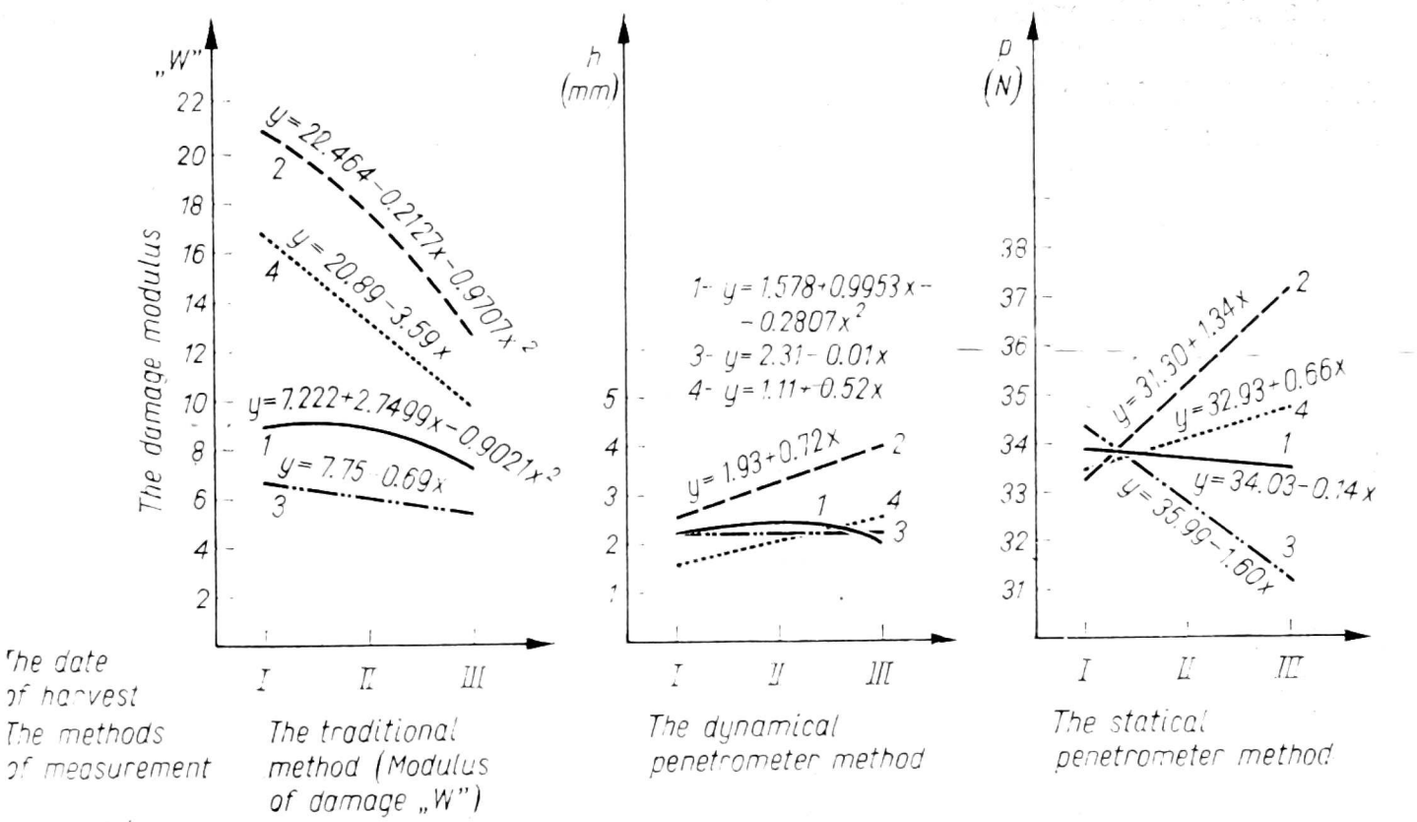


Fig. 3. The tuber damage as the effect of variety time of haulm destruction and the date harvest. The comparison of three methods of damage estimation. *1* — Uran and 3 — Flisak — early time of the haulm destruction, *2* — Uran and 4 — Flisak — late time of the haulm destruction

maturing. At the third time-limit of harvest, a decrease in mechanical damage is observed. Agreement of penetrometer readings with real damage was found only with late lifting i.e., after haulm destruction during maturing.

In view of the fact, that mechanical damages during harvest are not satifactory reflected in penetrometers readings it is necessery to undertake further studies on new methods improving correlations between mechanical damage and tuber resistance.

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## METODY POMIARÓW ODPORNOŚCI BULW NA USZKODZENIA MECHANICZNE

Streszczenie

W komunikacie przedstawiono dotychczasowe metody pomiarów uszkodzeń ziemniaków w aspekcie statycznym i dynamicznym.

W metodzie statycznej uwzględniono pomiary wytrzymałości skórki, stosując penetrometr statyczny, wytrzymałości miąższu, stosując kontrolowany nacisk na tkankę miąższu, oraz podatność na zgniatanie hydrostatyczne.

W metodach dynamicznych przedstawiono sposoby oceny uszkodzeń po zadziałaniu maszyn roboczych, pomiary wytrzymałości na uderzenie po przyłożeniu kontrolowanej siły, pomiary elastyczności wykorzystując penetrometr wahadłowy oraz pomiar wytrzymałości bulwy przy spadku z różnych wysokości na różny rodzaj podłoża.

Badania własne dotyczyły wrażliwości bulw na uszkodzenia mechaniczne mierzone metodami statycznymi i dynamicznymi. Celem ich było uchwycenie zależności między laboratoryjnymi metodami pomiaru a faktycznymi uszkodzeniami występującymi w czasie zbioru w warunkach produkcyjnych. Na podstawie dotychczasowych wyników nie udało się stwierdzić w zadowalającym stopniu zależności między laboratoryjnymi pomiarami a faktycznymi uszkodzeniami. Konieczne są dalsze poszukiwania metod pozwalających na dokładną charakterystykę bulw pod względem odporności na uszkodzenia mechaniczne.

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## МЕТОДЫ ИЗМЕРЕНИЯ УСТОЙЧИВОСТИ КЛУБНЕЙ ПРОТИВ МЕХАНИЧЕСКИХ ПОВРЕЖДЕНИЙ

Резюме

В сообщении представлены на основании прежней литературы методы измерений повреждений клубней картофеля со статической и механической точек зрения.

В статических методах учтены следующие измерения прочности кожуры (с применением статического пенетрометра, сопротивления мякоти клубней (с применением контролируемого давления на ткань мякоти) и чувствительности клубней к сдавливанию (способность к радиальной компресии).

В динамических методах представлены способы оценки повреждений после работы машин, измерения прочности на удар после приложения контролируемой силы, измерения пластичности с применением маятникового пенетрометра и измерения прочности клубней на падение с различной высоты и на различные поверхности.

Собственные исследования касались устойчивости клубней к механическим повреждениям, измеряемым статическими и динамическими методами. Цель их состояла в установлении зависимости между лабораторными методами измерений и фактическими повреждениями во время уборки в полевых условиях. На основании результатов, полученных до сих пор, не удалось установить в удовлетворительной степени зависимости между лабораторными исследованиями и фактическим повреждением, и потому необходимы дальнейшие поиски методов, позволяющих получить подробную характеристику клубней по их устойчивости против механических повреждений.

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