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FACTORS DETERMINING THE RESISTANCE OF RAPE SEEDS TO DAMAGE*

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A b s t r a c t. Laboratory studies on rape seeds, conducted at the Institute of Agrophysics, PAS, were aimed at the determination of their strength properties in the aspect of the susceptibility of the seeds to damage. Limit values were determined for loads causing the disruption of the seed cover, with relation to varietal features, agrotechnical measures applied (crop spraying, time of harvest - plant ripeness, sowing density), temperature, and seed moisture content. The value of force causing seed cover cracking, the corresponding strain, or the value of energy and the apparent modulus of elasticity clearly defined the resistance of individual seeds under loading.

The mechanical parameters studied were differentiated for particular plant varieties, however, differences in particular years of the study were statistically insignificant, while the differences between successive years of the study but for the same variety were significant. Generally it was observed that seeds of all the varieties in 1993 were more resistant to external loads. No statistically significant changes were observed in seed strength with relation to plant ripeness (time of harvest). Assessing the effect of chemical preparations used for rape spraying, no statistically significant effect on the strength parameters under study was noted for any of the preparations with relation to the control. Experiments concerned with the effect of sowing density on the strength properties of rape seeds did not show any significant differences of the particular parameters with relation to four sowing densities (50, 35, 20 and 10 plants/m^2). The strongest differentiation of the properties under study was noted in the case of seeds with increased moisture content. An increase in the seed moisture content was accompanied by a distinct decrease in the values of force, strain, energy, and modulus of elasticity, the greatest decrease in the values of the parameters being observed for moisture content between 11 and 17 %. Also, a significant effect of seed temperature on the strength parameters under study was observed. With increasing temperature, the values of all the parameters decreased. The effect of seed temperature was stronger for dry seeds and decreased with increasing seed moisture content.

K e y w o r d s: rape, strength, varietal features, ripeness, crop spraying

INTRODUCTION

Mechanical properties, resistance to the effect of external forces, and the range of variability of strength properties resulting from the effect of various external and internal factors have a decisive importance for the occurrence of mechanical damage to rape seeds. Knowledge of these problems will facilitate the determination of causes of seed cover damage and will help obtain seed material of high qualitative parameters. Studies on the extent of damage to various seeds and the causes of such damage have been conducted in Poland and abroad. Fiscus *et al.* [2] studied the effect of various methods of cereal grain processing on the extent of mechanical damage occurring in the course of such operations. Gieroba and Dreszer [3,4] described the sources of the occurrence of seed damage during

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combine harvesting and as a result of seed transport with worm and scraper conveyors. Grundas *et al.* [5] dealt with damage to wheat grain and with losses resulting from such damage. Szot and Stępniewski [7-9] described the mechanical properties of rape in the aspect of quantitative and qualitative losses during and after harvest. Davidson *et al.* [1] studied the strength properties of rape seeds from the viewpoint of damage to seed cover. Kustermann and Kutzbach [6], in turn, studied the effect of the rate of deformation on the strength of corn, and determined the relationship between the apparent modulus of elasticity and the rate of deformation.

This study was performed to determine the values and the variability of the basic strength properties of rape seeds with relation to various agrotechnical measures, degree of ripeness, varietal features, moisture content, and temperature.

MATERIAL AND METHOD

The variability of the strength properties and the critical values of rape seed loading were studied with the help of an INSTRON strength tester. Test of quasi-static compression of individual rape seeds between two parallel plates were conducted. The course of the curve in the force-strain system was recorded by means of a computer interfaced through an analog-digital converter to the strength tester.

The stand for the measurement of the strength properties and the critical load values of rape seeds was set up around an INSTRON Model 6022 strength tester (Fig. 1).

The stand consisted of the following:

- an air tight seed container, washed over with heating fluid,
- a thermometer,
- a thermostat with heating fluid pump,
- a contact thermometer for temperature control,
- a measurement head,
- a thermal chamber, one of the heater plates of which was attached to the measurement head and the other one was fixed to the strength tester.

Analog signal from the measurement head, coming from the amplifiers of the strength tester, was converted into a digital signal in the measurement interface and fed to the computer. Specially developed software permitted computer recording of compression curves, which allowed for later processing of the data according to the adopted calculation formula.

To determine the variability of the strength properties of rape seeds, the authors took under consideration the apparent modulus of elasticity of an individual seed, the energy required to damage the seed cover, and the maximum force that a seed can withstand, together with the corresponding strain. The modulus of elasticity was calculated on the basis of a straight section of the compression curve, using the Hertz theory according to the interpretation presented in Fig. 2, according to the formula:

$$E = \frac{1.061\,(1-\mu^2)}{\pi}\sqrt{\frac{K^3}{R}}\sqrt{\frac{(\Delta F)^2}{(\Delta d)^3}} \qquad (1)$$

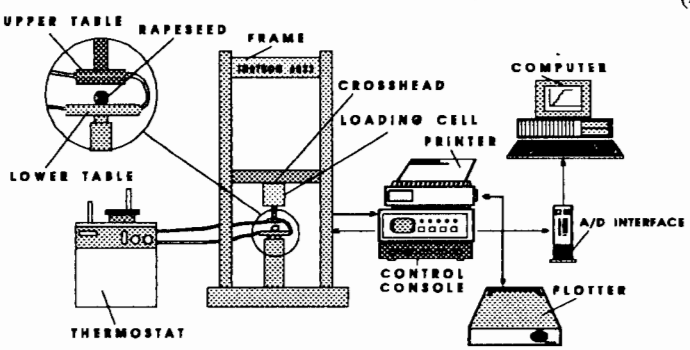


Fig. 1. The stand for the measurement of the strength properties and the critical values of load for rape seeds.

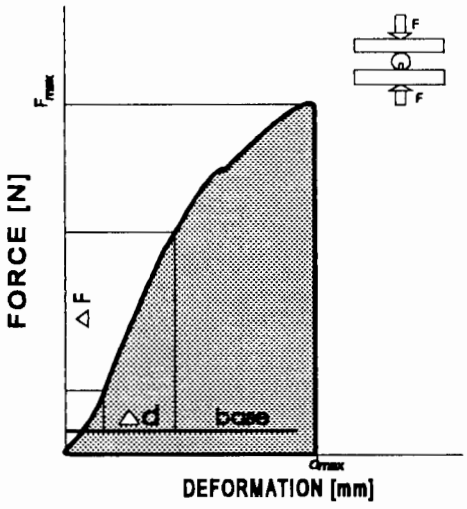


Fig. 2. Typical compression curve for an individual rape seed, showing the characteristic mechanical parameters and the interpretation for the calculation of the modulus of elasticity.

where μ - Poisson coefficient, K - constant, R - radius of seed curvature (mm), ΔF - difference of force values (N), Δd - difference of strain values (mm).

Material for the tests was taken from a field experiment, and the factors affecting the strength properties of the seeds were the following:

- seed moisture content (5 levels: 4, 7, 11, 14 and 17 %),
- seed temperature (5 levels: 20, 30, 40, 50 and 50 °C),
- degree of ripeness (4 harvest times: early, optimum, late, very late),
- varietal features (4 varieties: Ceres, Liporta, Mar, Bolko),
- agrotechnical measures (3 types of spraying: Spodnam, Harvade, Reglone; 4 sowing densities: 50, 35, 20 and 10 plants/m^2).

The assumed levels of seed temperature were obtained with the help of the thermostat, while the levels of seed moisture content of 11, 14 and 17 % were achieved through conditioning air-dry seeds (8 %) in air tight plastic containers, to which the required amounts of distilled water were added. The moisture content of 4 % was obtained by drying air-dry seeds for 2 h in a stream of air heated to 40 °C.

RESULTS

The strength properties of rape seed were assessed from the viewpoint of the susceptibility of seeds to damage. The force causing seed cover cracking, the corresponding value of strain, force within the conventional boundaries of elasticity, as well as the energy and the modulus of elasticity, clearly defined the resistance of individual seeds in the course of load application.

Figure 3 presents a comparison of the aforementioned properties of the varieties under study. No major differences were observed, only certain tendencies (lack of statistically significant differences). The maximum force causing damage to seed cover was differentiated among the particular varieties, though in the years of the study the differences were not significant statistically. The differences between the successive years, however, were statistically significant. Generally, it was noted that the seeds of all the varieties in 1993 were more resistant to external load, which is supported by the higher values of maximum force and similar tendencies in the case of the forces of elasticity, at lower strain for both the maximum forces and the elasticity. The values of energy required to damage the seed cover were significantly lower in 1992 than in the other years. Likewise, the apparent modulus of elasticity was the highest in 1993, with no significant differences between the varieties under study. In 1992 and 1994 the apparent modulus of elasticity remained at a similar level.

The effect of the degree of seed ripeness on its strength was studied on the Liporta variety (Fig. 4). Also here no significant differences were observed with relation to three harvest times characterizing different degrees of ripeness. The highest values of the strength parameters were observed for seeds from the retarded harvest, while at the other two harvest times the seeds showed similar values of the parameters studied.

Assessing the effect of chemical preparations used for rape spraying, no statistically significant effect of any of the preparations on

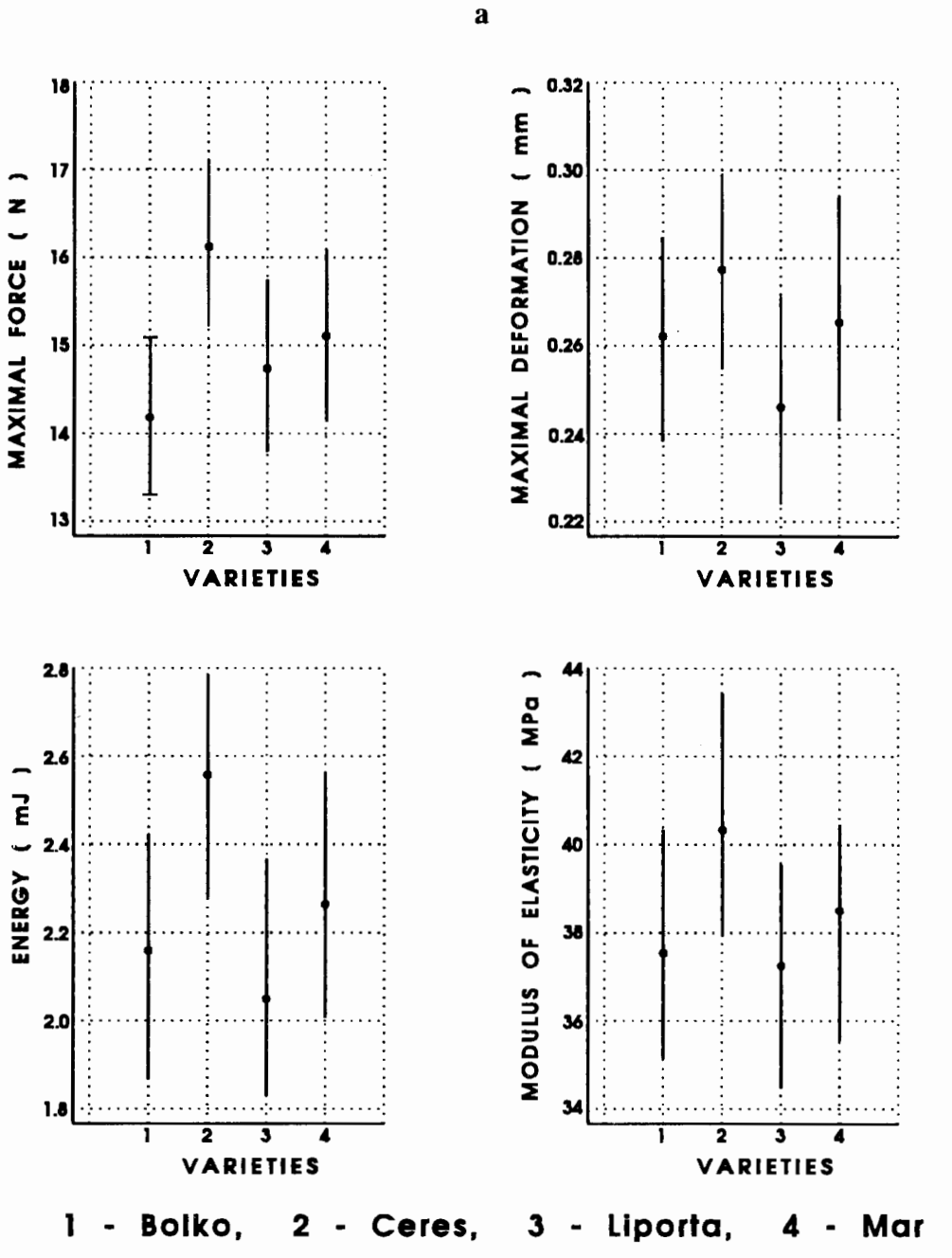
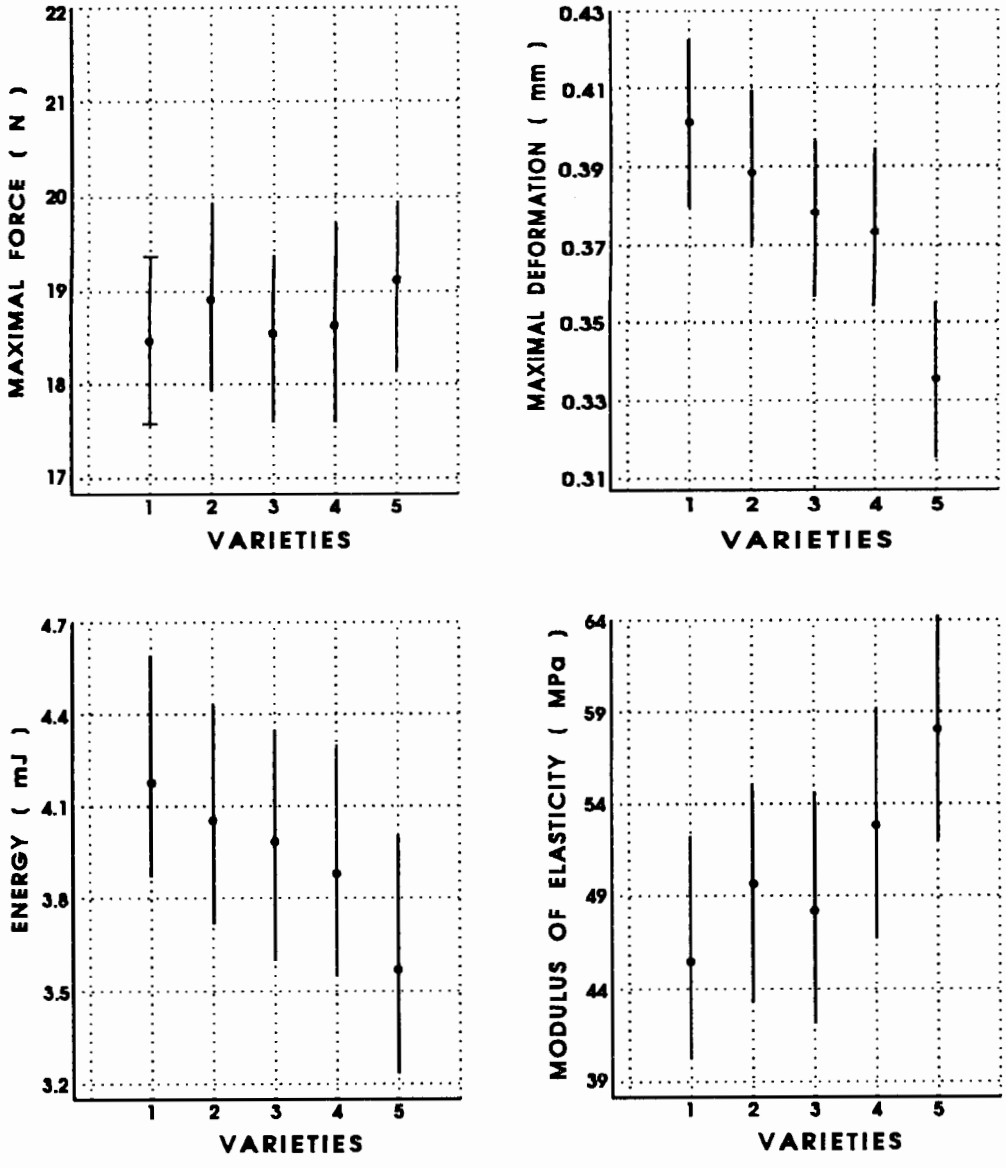


Fig. 3. The effect of varietal features on the strength properties of seed rape in 1992 (a), 1993 (b) and 1994 (c).

b



1 - Bolko, 2 - Leo, 3 - Libravo, 4 - Mar, 5 - Ceres

Fig. 3. Continuation.

c

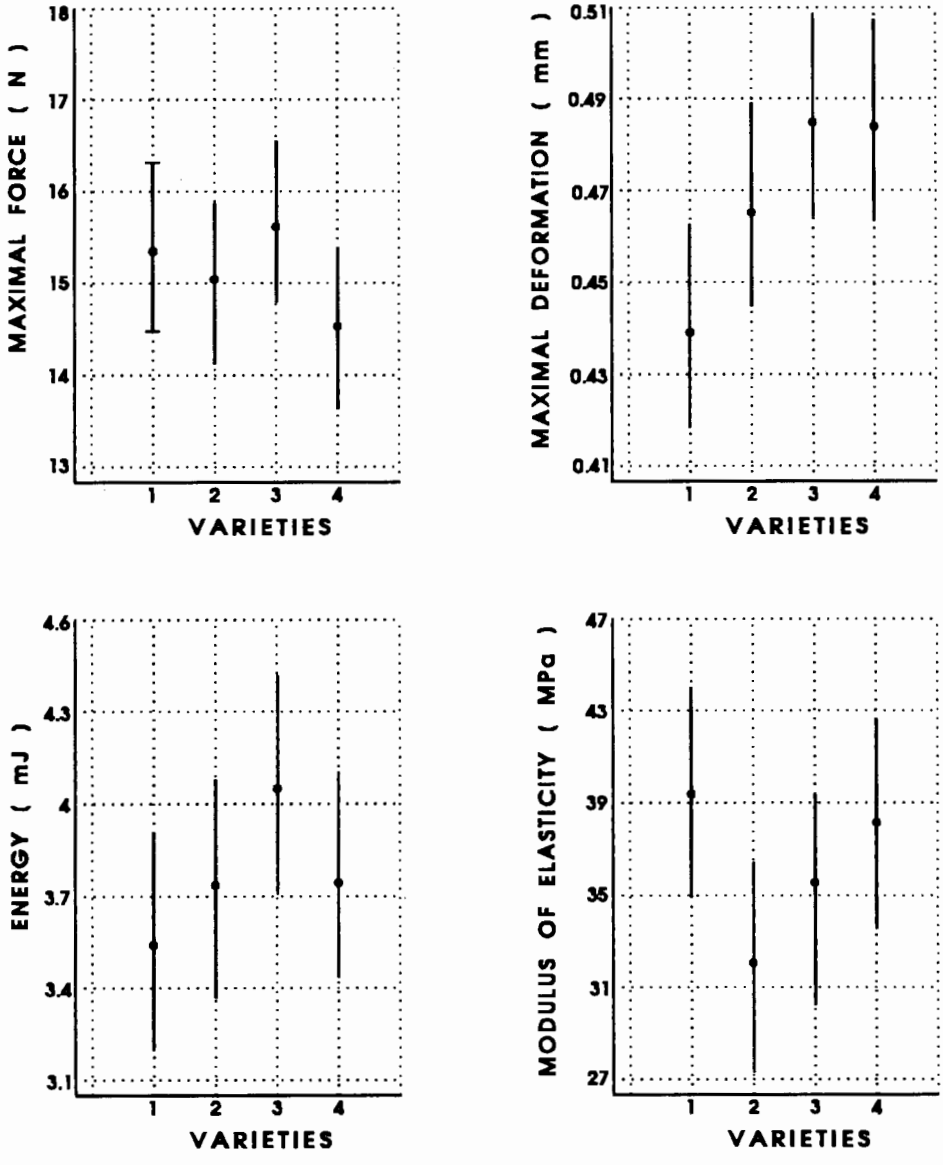


Fig. 3. Continuation.

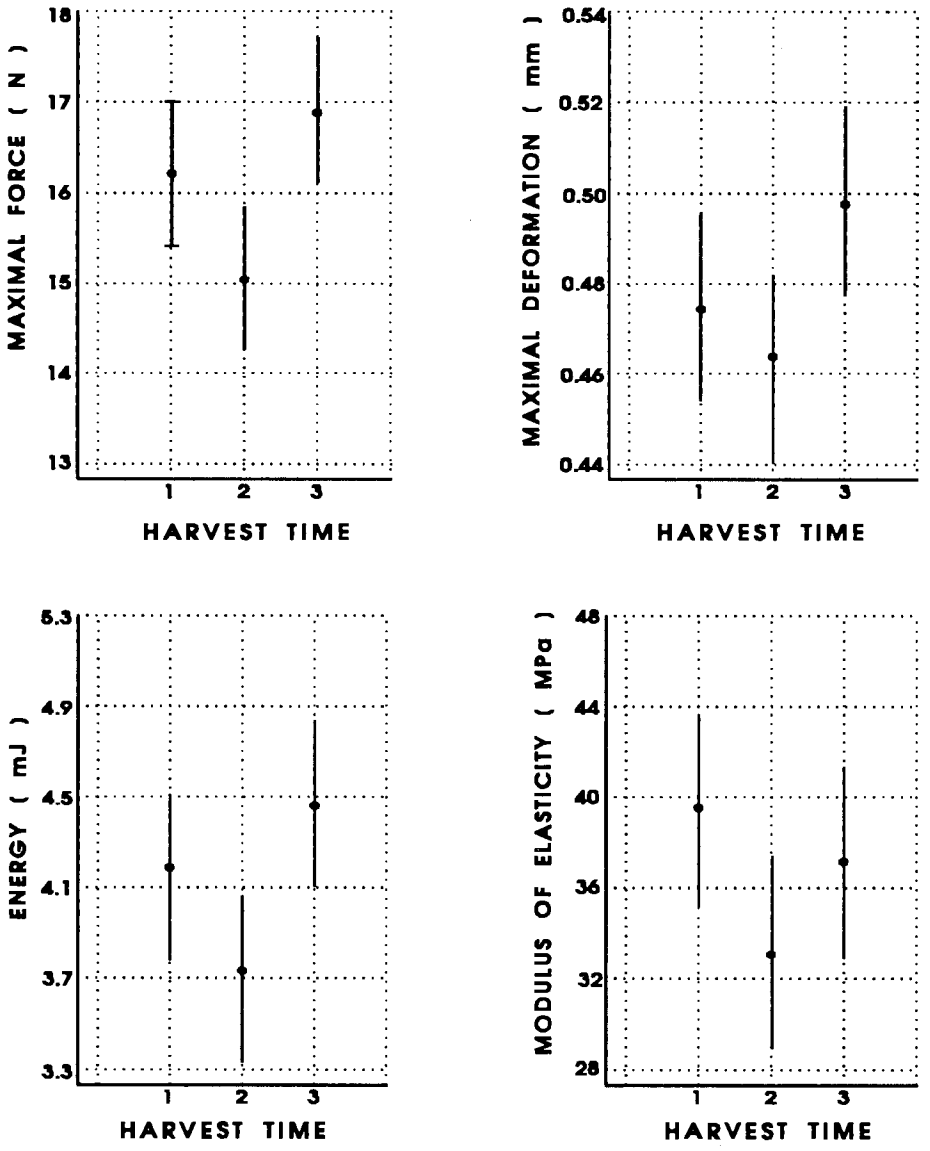


Fig. 4. The effect of seed ripeness on the strength parameters of rape seed (Liporta).

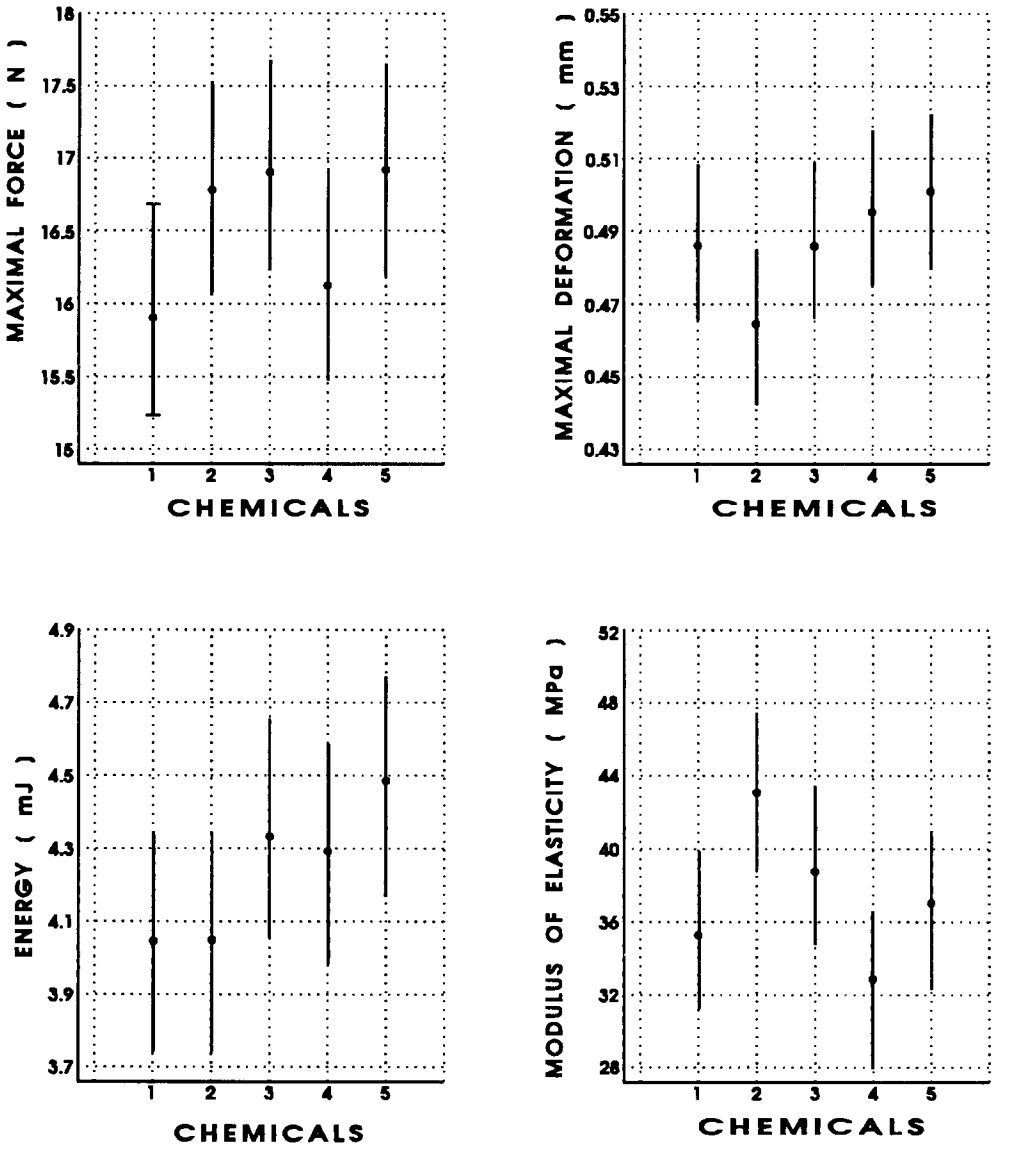


Fig. 5. The effect of spraying on the strength parameters of rape seed (Ceres).

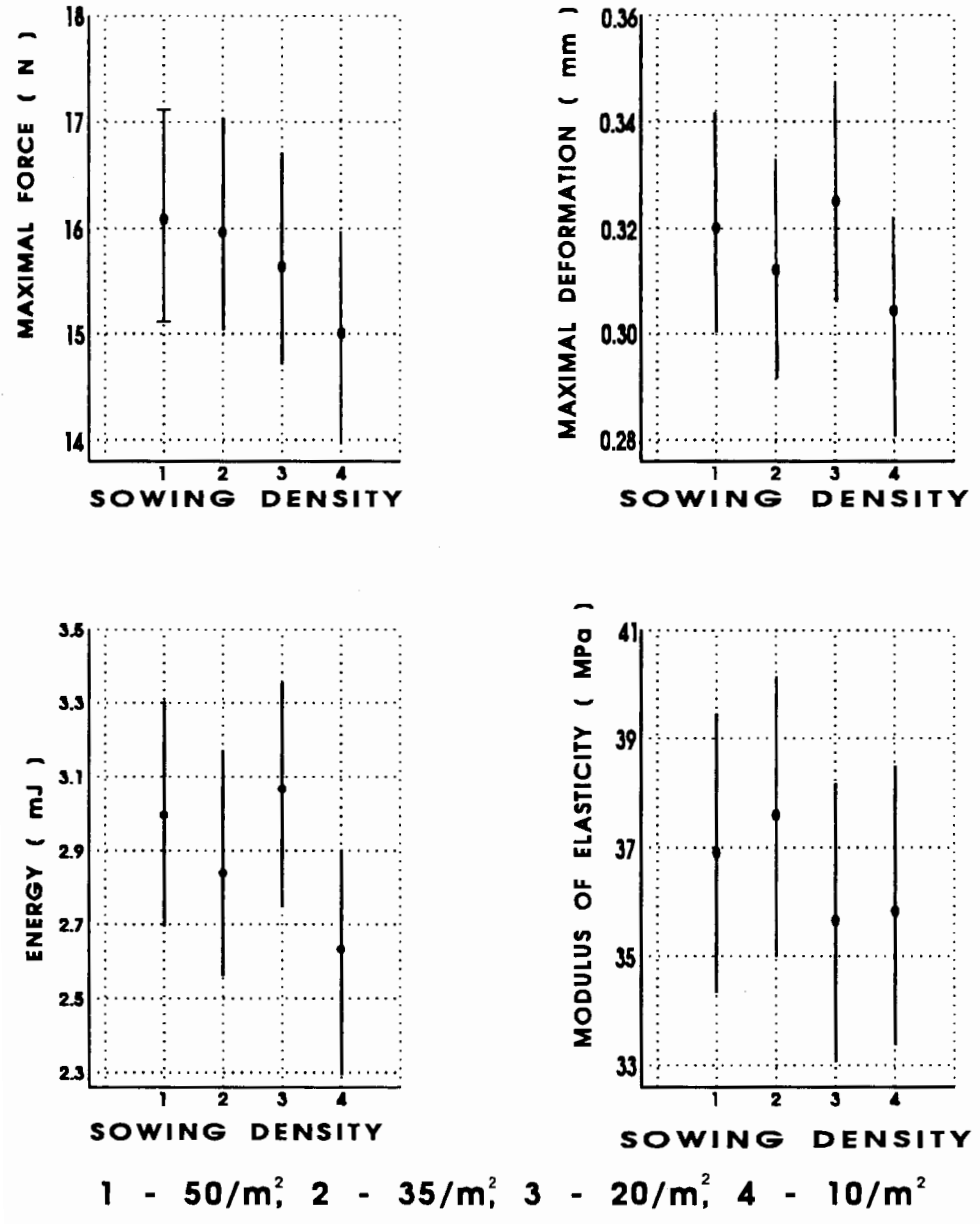


Fig. 6. The effect of sowing density on the strength parameters of rape seed (Liporta).

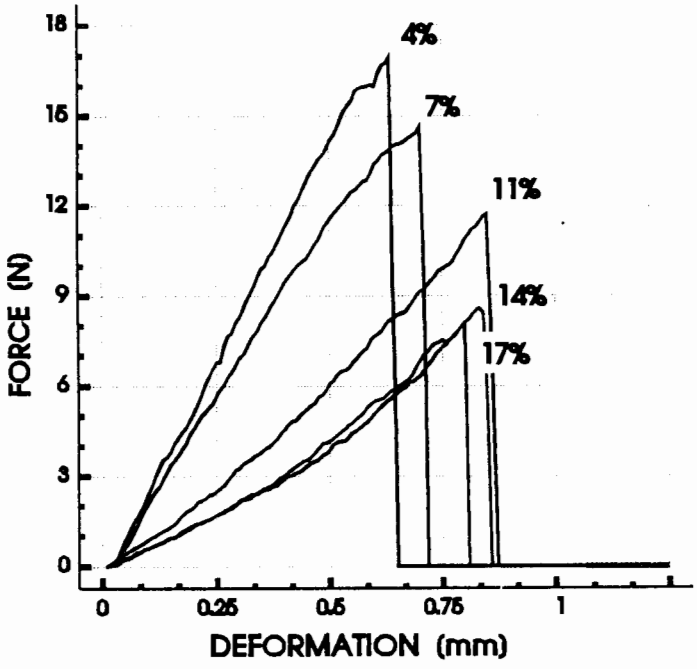


Fig. 7. The effect of seed moisture content on the force and destructive deformation of rape seeds of the Ceres variety (20 °C).

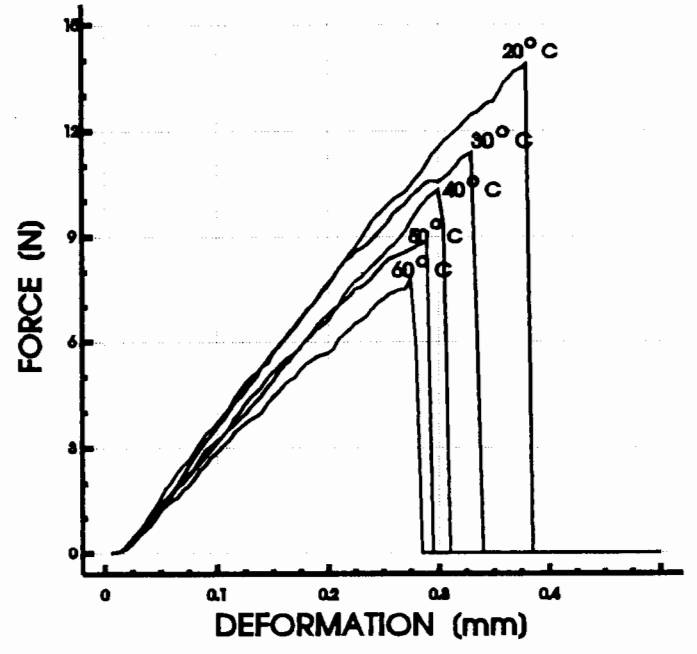


Fig. 8. The effect of seed temperature on the force and destructive deformation of rape seeds of the Ceres variety (moisture content of 7 %).

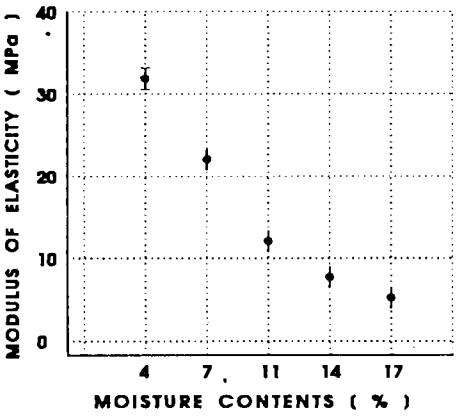


Fig. 9. The effect of seed moisture content on the modulus of elasticity of rape seeds.

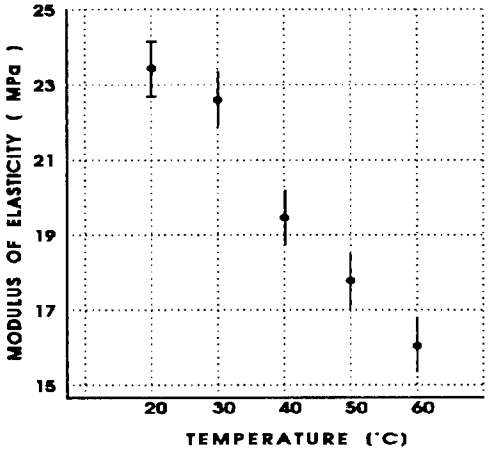


Fig. 10. The effect of seed temperature on the modulus of elasticity of rape seeds.

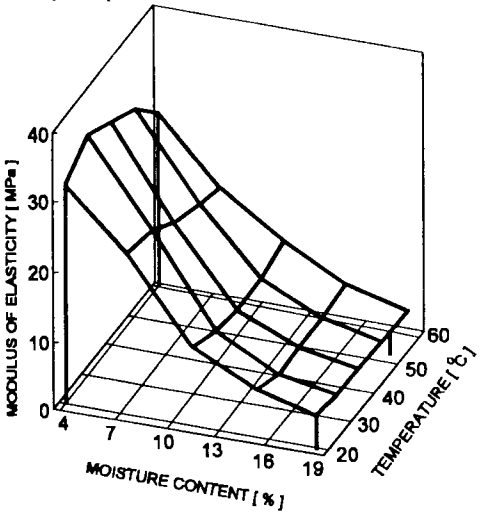


Fig. 11. The effect of seed moisture content and temperature on the apparent modulus of elasticity of rape seeds.

the seed strength parameters was observed with relation to the control (Fig. 5). Similar results were obtained in all the years of the study.

In 1992 an experiment was made on the effect of sowing density on the mechanical strength of rape seeds (Fig. 6). No significant differences were observed in the values of the particular parameters with relation to the four sowing densities (50, 35, 20 and 10 plants per m^2).

The strongest differentiation in the values of the properties under study was noted in the case of seeds of varied seed moisture content. Figure 7 presents characteristic changes in the shape of the compression curves of rape seeds with relation to the seed moisture content. A decrease was noted in the inclination of the curve to the axis of abscissae, i.e., with increasing seed moisture content the same deformation caused a lower strain. Also meaningful was the decrease in the maximum force borne by the seed and the increase in the value of the maximum deformation.

The effect of seed temperature on the strength parameters under study was also found to be significant (Fig. 8). An increase in seed temperature resulted in a decrease both in the value of the maximum force and in the value of deformation causing seed cover cracking. However, the inclination of the compression curve towards the axis of abscissae remained virtually constant for the range of temperatures under study (especially for low deformations). With increasing seed moisture content, there was a decisive decrease in the values of the force, deformation, energy, and modulus of elasticity (Fig. 9). It should be noted that the strongest drop in the values of these parameters was observed within the range of seed moisture from 11 to 17 %. Likewise, an increase in seed temperature was accompanied by a decrease in the values of the force, deformation, energy, and modulus of elasticity (Fig. 10). The effect of seed temperature was stronger for dry seeds, and decreased with increasing seed moisture content (Fig. 11).

CONCLUSIONS

1. The strength properties of seeds of the particular varieties of rape differed significantly with relation to the year in which they were harvested. Parameters describing the mechanical properties of seeds harvested in 1992 and 1994 had lower values than the parameters of seeds from the harvest of 1993.

2. No statistically significant differences in the values of the strength parameters were observed between the varieties under study (in a given year). The only exception was the tendency of the Ceres variety for elastic deformation of seeds to occur at higher loads and strains with relation to the other varieties. This tendency was observed in all years of the study.

3. The degree of ripeness of seeds had an effect on the values of the apparent modulus of elasticity, energy causing damage, and deformation, maximum as well as elastic, but the differences were not statistically significant. Seeds harvested earlier were characterized by a high modulus of elasticity and energy required to damage the seed, while the forces of elasticity and the maximum forces decreased with progressing ripeness, and the level of deformation had a tendency to increase.

4. Experiments on the effect of sowing density on the strength properties of rape seeds did not show any significant effect of that factor on the properties studied. For all the sowing densities used, no identifiable tendencies were observed in the changes in the values of force and destructive deformation or in the values of destructive energy and the modulus of elasticity.

5. Likewise, no effect of spraying on the mechanical parameters of rape seed was observed. None of the preparations used caused statistically significant differences in the values of the parameters studied with relation to the control sample on which no chemical spraying was applied.

6. Seed moisture content was the factor which most strongly affected the values of the strength parameters. With increasing seed moisture content, the force causing seed cover cracking decreased, the corresponding deformation increased, the destructive energy and the apparent modulus of elasticity decreased.

7. Seed temperature also affected the mechanical properties of rape seeds. An increase in seed temperature had a decreasing effect on the force, energy, and apparent modulus of elasticity, and an increasing effect on the deformation causing seed cover cracking.

8. The relation between seed temperature and seed moisture content was such that the strongest effect of temperature was observed in the case of dry seeds, and decreased with increasing seed moisture content.

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CZYNNIKI DETERMINUJĄCE ODPORNOŚĆ NASION RZEPAKU NA USZKODZENIA

Badania laboratoryjne nasion rzepaku prowadzone w Instytucie Agrofizyki PAN w Lublinie miały na celu określenie ich cech wytrzymałościowych pod kątem podatności nasion na uszkodzenia. Określono graniczne wartości obciążeń, które powodują rozerwanie okrywy

nasiennej w zależności od cech odmianowych, zabiegów agrotechnicznych (opryski, termin zbioru - dojrzałość, obsada roślin) oraz temperatury i wilgotności nasion. Siła powodująca pęknięcie okrywy nasiennej, odpowiadające jej odkształcenie, jak też energia i pozorny moduł sprężystości w sposób jednoznaczny opisywały wytrzymałość pojedynczych nasion podczas ich obciążania.

Badane parametry mechaniczne były zróżnicowane dla poszczególnych odmian, jednak różnice w poszczególnych latach były nieistotne statystycznie, natomiast różnice te pomiędzy kolejnymi latami dla tej samej odmiany były istotne. Generalnie zauważono, że nasiona wszystkich odmian w 1993 roku były bardziej odporne na obciążenia zewnętrzne. Nie zanotowano również istotnych statystycznie zmian wytrzymałości nasion w zależności od dojrzałości (terminu zbioru). Oceniając wpływ preparatów chemicznych stosowanych do oprysków rzepaku nie stwierdzono istotnego statystycznie wpływu któregokolwiek preparatu na badane parametry wytrzymałościowe w stosunku do próby kontrolnej. Badania dotyczące wpływu gęstości siewu roślin na wytrzymałość mechaniczną nasion rzepaku nie wykazały istotnych różnic poszczególnych parametrów w zależności od czterech gęstości siewu (50, 35, 20 i 10 rośl/m^2). Natomiast największe zróżnicowanie badanych cech wystąpiło dla nasion o podwyższonej wilgotności. Wraz ze wzrostem wilgotności w zasadniczy sposób spadały wartości siły, odkształcenia, energii i modułu sprężystości, a największy spadek tych parametrów zanotowano w przedziale pomiędzy 11 a 17 % wilgotności nasion. Stwierdzono również istotny wpływ temperatury nasion na badane parametry wytrzymałościowe. Ze wzrostem temperatury nasion malały wartości wszystkich badanych parametrów. Wpływ temperatury był większy dla nasion suchych i malał ze wzrostem wilgotności.

S ł o w a k l u c z o w e: rzepak, wytrzymałość, cechy odmianowe, dojrzałość, opryski.