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EFFECT OF SPATIAL ORIENTATION OF RAPESEED ON ITS STRENGTH*

A. Stępniewski[1], *H.D. Kutzbach*[2], *B. Szot*[1]

[1]Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-236 Lublin, Poland
[2]Institute of Agrotechnics, Hohenheim University, 7 000 Stuttgart 70, Germany

A b s t r a c t. Grains, seeds, fruits and other agriculture products have nonregular shape. Except of that they have also nonhomogeneous structure and built (i.e. two cotyledons). These two factors among others affected strength of plant material.

Rapeseeds are regarded as balls. In fact their shape is similar to the ball, but measuring individual seed in three planes, it is easy to notice differences between dimensions. Each seed consisted of skin, two cotyledons and germ. This anatomical built as well as geometrical dimensions influence on mechanical properties. However, in this considerations shape of seeds was neglected and only inner built was under study.

The quasi-static compression test was carried out on individual seed. Seeds were orientated in respect to the dividing plane of cotyledons. Compression curves were registered in force-deformation coordinate system. Maximal damaging force with corresponded deformation as well as damaging energy and modulus of elasticity were calculated.

Investigations confirmed differentiated strength features of rapeseed in various plains. The differences were statisticaly significant and the highest mechanical parameters occurred for position, in which compression force acted perpendicular to the dividing plane of cotyledons.

K e y w o r d s: rapeseed, strength, spatial orientation

INTRODUCTION

Agricultural material characterizes considerable variability of physical properties. This variability came out not only from external conditions of grow (type of soil, fertilization, weather conditions, etc.), but also from internal features of seeds as: size, shape, moisture content, variety features.

Rape seeds, reckoned in theoretical considerations as balls, do not represent ideal sphere and their dimensions differ, when measured in three plans. Apart from different radius of curvature caused by internal structure - two cotyledons, a germ introduces the next irregularity.

The above mentioned aspects influence mechanical strength of seeds, which could be different according to direction of loading. The present study was conducted in order to estimate variability of strength features of single rapeseed in the aspect of its spatial orientation, i.e. direction of loading.

MATERIAL AND METHOD

Two rapeseed varieties: Liratop and Bolko were taken into consideration. Liratop variety was purchased at Wilhelm Schoell GmbH, Stuttgart - Plieningen. Seeds were bought as sowing material. Seeds of Bolko variety came from field experiment of the Institute of Agrophysics of the Polish Academy of Sciences.

Seeds were separated on sieves before the test in order to achieve material of equal dimensions (diameter). Only seeds which came through holes of 1.9 mm and did not come through 2 mm holes were taken for

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the investigation. Seeds with irregular shape and with broken cover were rejected at the same time. The moisture content was natural air dry moisture equal 7 % w.b.

The quasi-static compression test of a single seed was chosen in order to estimate rape mechanical strength. Every seed was positioned between two parallel plates fixed into testing machine. Three positions were distinguished according to the dividing plane of two cotyledons and the germ (Fig. 1). The first one was, when the dividing plane laid horizontal, parallel to the compression plates. The next position was with this plane placed vertical, perpendicular to the compression plates. The third position was established, when dividing plane of cotyledons was placed vertical, perpendicular to the compression plates, with a germ situated on one of the plates. Plates were fixed into the INSTRON testing machine. Seeds were deformed with velocity of 10 mm/min. Signal from the machine was registered with the personal computer, connected to the INSTRON through analog-digital converter. Curve in force-deformation coordinate system was obtained (Fig. 2). The following parameters were derived from the curve:

- maximal compression force,
- deformation corresponding to the maximal force,
- force causing first indivertible change (rapture),
- deformation corresponding to this force, energy required to the total damage of seed,
- apparent modulus of elasticity.

The force causing the first indivertible change and deformation corresponded to it were considered as limits of elasticity. These limits were stated in the point where compression curve showed nonlinearity (deviated) and were obtained by drawing tangential to the linear part of the curve. Deviation occurred next to the last common point of tangential and compression curve.

Apparent modulus of elasticity was calculated from the linear part of the curve, according to Hertz theory:

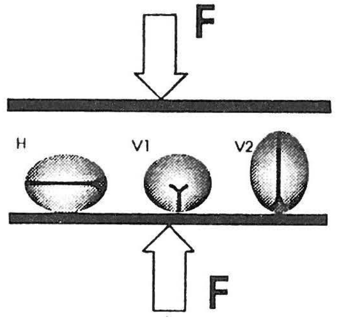

Fig. 1. Three positions of compressed seed distinguished according to internal built of rapeseed: H) dividing plain of cotyledons parallel to compresion plates, V1) dividing plain of cotyledons perpendicular to compression plates, V2) dividing plain of cotyledons perpendicular to compression plates with a germ placed on a plate.

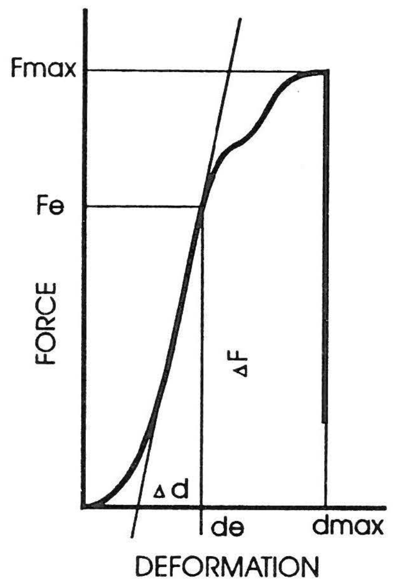

Fig. 2. Compression curve in force-deformation coordinate system and a scheme of calculation of apparent modulus of elasticity.

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

where μ - Poisson's ratio, K - constant R - radius of seed curvature, ΔF - force in the linear part of compression curve, Δd - deformation of the seed.

The constant K was assumed as equal to 1.3514 and Poisson's ratio as 0.4. Every combination of the investigation consisted of 25 replications.

Analysis of variance with confidence level of 95 % was made in order to estimate confidence intervals and significance of differences between measured values.

RESULTS

Considerable differentiation of the tested mechanical parameters was observed for both varieties according to the orientation of the compressed seed. Significant differences occurred both among studied positions and between varieties.

First parameter - elastic force (Fig. 3a) was the biggest for Bolko variety and reached at average 12 N for position with horizontal dividing plane BH. This value was significantly different than values of elastic force derived at other two seed positions, which also significantly differentiated. The value at first vertical position BV1 was 8.9 N, while at the second BV2 was 6.89 N. Values of elastic forces for Liratop were smaller than the same values for Bolko, apart from first vertical position. Values at vertical position LV1 (8.92 N) and at horizontal position LH

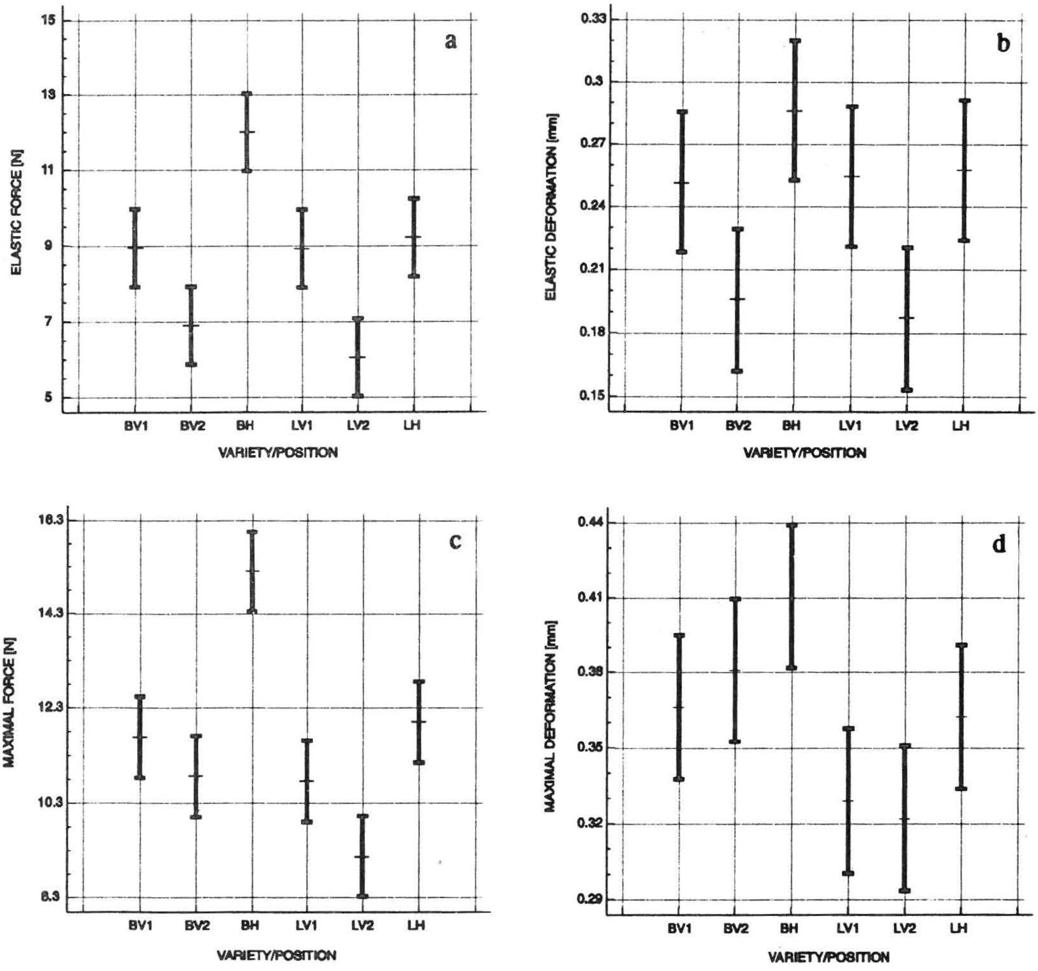

Fig. 3. Mean values with confidence intervals of elastic force (a), elastic deformation (b), maximal force (c), maximal deformation (d) of compressed seeds.

(9.21 N) did not differ significantly between themselves, but both were significantly different than force values at second vertical position LV2 (6.06 N).

The deformation corresponded to the elastic force (Fig. 3b) varied according to the position, and was significantly different between second vertical position and horizontal position for both varieties. The biggest elastic deformation was obtained at horizontal position of Bolko (0.29 mm at the average) and the smallest for second vertical position of Liratop (0.19 mm at the average). Corresponding deformation values for both varieties behaved similar.

Maximal force, which damaged seeds (Fig. 3c) reached the biggest value at horizontal position of Bolko and was 15.2 N at the average. Other two vertical positions of Bolko did not differ significantly and the first BV1 was at the average 11.69 N and the second BV2 10.86 N. Similarly for Liratop, the biggest damaging force 12.01 N was at horizontal position, and the smallest 9.18 N at vertical position LV2. The average maximal force at first vertical position was 10.76 N.

The deformation causing seed damage (Fig. 3d) did not differ significantly among tested positions as well as between corresponded values for both varieties. However, the tendency was observed that the biggest deformations were at horizontal positions - BH 0.41 mm, LH 0.36 mm. The lowest deformation occurred for seeds of Liratop at second vertical position - LV2 0.33 mm, while at the analogous position of Bolko this value was equal 0.37 mm.

Energy required to seed damage (Fig. 4) varied from 1.59 mJ at second vertical position of Liratop to 3.49 mJ at horizontal position of Bolko. The significant differences occurred between horizontal position of Bolko and two other positions of this variety. Values of damaging energy of Liratop did not differ significantly among tested seed positions.

The same situation was noticed for modulus of elasticity (Fig. 5). Values of this parameter did not differ significantly among both positions and varieties. Although tendency was observed that the biggest value of modulus was for second vertical position - BV2 30.91 MPa and LV2 23.66 MPa.

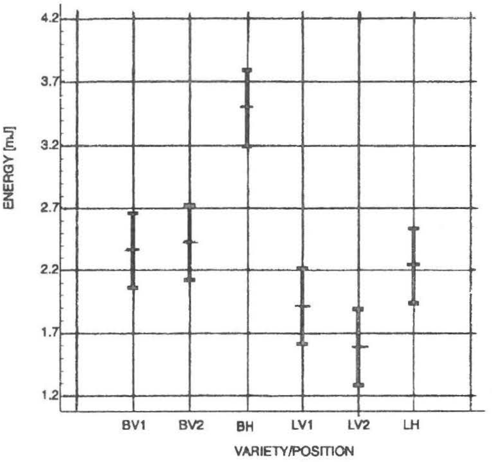

Fig. 4. Mean values with confidence intervals of damaging energy of seeds.

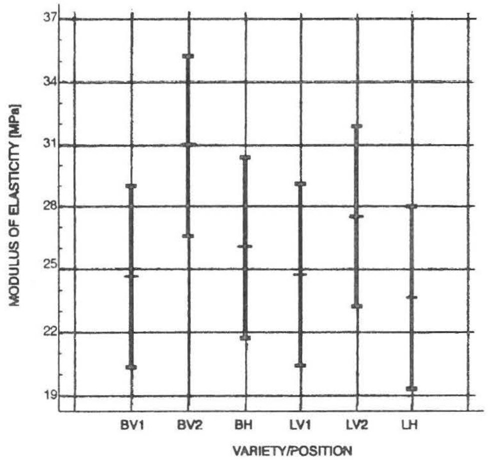

Fig. 5. Mean values with confidence intervals of apparent modulus of elasticity of seeds.

DISCUSSION

Summarized, it should be stated that seeds could be more deformed, when compressed at horizontal position and also they stood higher loads at this position. Also energy required to seed damage was bigger at horizontal position. Nevertheless modulus of elasticity was the biggest at vertical position with a germ placed on the compression plate.

This could have connection with irregular shape of seeds. Both dimensions and area of cross-section of seeds were estimated as differentiated, but they were too difficult to measure. Also the differences in shape between varieties were observed. Bolko had seeds longer and flatter than Liratop, which seeds were more similar to the balls. However, only correlation of geometrical dimensions of each seed with its strength parameters could explain this hypothesis. Simple sieve separation seems to be insufficient.

The shape of seeds could also influence the variability of tested parameters. This variability (see confidence intervals) was smaller for Liratop (more round seeds), than for Bolko.

CONCLUSIONS

1. The resistance to damage of rapeseed in compression test depended on seed orientation according to the dividing plane of cotyledons and the direction of compression.

2. Seeds at the position with dividing plane parallel to compression plates could stay the highest loads and the biggest deformations. Also energy needed to damage was the biggest at this position.

3. Modulus of elasticity did not differ significantly for each position, but its higher values were observed at vertical position with germ placed on the compression plates.

4. In general Bolko was more resistant to damage than Liratop, both according to loads, deformations, damaging energy and modulus of elasticity.

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