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OBSERVATIONS ON THE CHARACTERISTICS OF THE STRENGTH OF PEA GRAINS

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Abstract. Observation of the dynamic strength of pea grains of 9.7% moisture content was considered. Grains were struck by a spinning jib with a circumferential speed from 0 to 12 m s^{-1}. The influence on the damage and germinating capacity of the weight of the individual grains, the direction of the strike on the grain, the design of the striking plate and the repeated striking on the grains investigated was observed. Pea grains damaged while growing were tested. An increase in the 'strike' speed on the grain to above 6 m s^{-1} markedly increased grain damage and decreased germinating capacity. Grains of medium weight have the best germinating capacity. Grains which have been damaged in the growing process have about a 6.7% lower germination capacity in relation to undamaged ones. No differences in damage were apparent on the cotyledon, radicle or plumule of the pea grain solely on account of the direction of the strike; however the design of the striking plate does have an influence on grain damage.

Keywords: pea, dynamic strength of grains, damage of grains, germinating capacity

INTRODUCTION

The threshing and post-harvest treatment of grain and pulses and also of cereals, corn, oil and other crops excessively damages them mechanically and as a consequence occasions a decrease in their quality and causes increased losses.

In order to understand the process of grain damage and the characteristics of grain strength, it is necessary to test that strength. In terms of the working mechanisms of harvesting machinery and the technological lines of the influence of post-harvest seed treatment, it is more meaningful to provide strength tests for seeds in dynamic conditions than statically [1-4]. Among the simplest of impact testing methods presented in the literature are those which strike the seeds, including the free fall of the seeds, throwing the seeds, striking the seeds with spring bumpers and striking them with spinning strike plates. A pendulum, to estimate the energy of the damage to the seed, was employed.

Experiments were focused on appraising the characteristics of the strength of the pea grains by impact loading. Low grain moisture (below 13%), was the main area of focus; this is typical in post-harvest treatment (grading, separating). A relatively minor impact on the grain and on pea grain quality was observed after the above mentioned experiment had been conducted.

The aim of the work was to observe the dynamic strength of pea grains when struck.

MATERIALS AND METHODS

The variety 'BELINDA' with a moisture content of 9.7% was used to test the dynamic strength of the pea grains which were observed when being struck Measurements were performed on a device manufactured by the Institute for Agricultural Machinery at the Rheinland Friedrich – Wilhelm University, Bonn (Artim, 1994) using a range of circumferential speeds on a spinning jib from 0 to 12 m s^{-1}.

The influence of the following factors on the damage and germinating capacity of pea grains [5] was observed:

- influence of striking speed intensity from 0-12 m s^{-1} with a gradation of 2 m s^{-1} steps,
- influence of damage occasioned in the growing process, which was divided into five groups,
- influence of the strike direction on the radicle, hilum and cotyledon of the grain (fig. 1),

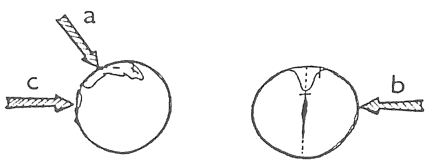

Fig. 1. Direction of the strike on the pea grain where: a – direction of the strike on the radicle, b – direction of the strike on the cotyledon, c – direction of the strike on the hilum

- influence of the strike plate design – strike plate area 8 x 8 mm, roller with hemispherical head of 2.7 and 8 mm in diameter,
- influence of repeated number of strikes, viz: 0, 1, 3, 5, 7 strikes,
- influence of grain weight (size) divided in order to consider distributing the variation of grain weight into 5 weight categories:

1. category – to 0.245 g.
2. category – from 0.246 to 0.265 g,
3. category – from 0.266 to 0.285 g,
4. category – from 0.286 to 0.305 g,
5. category – above 0.306 g.

The relations of the observed values were statistically evaluated (tab. 1).

RESULTS - DISCUSSION

By observing the influence of the circumferential speed intensity of the strike of the spinning jib, the germinating capacity of grain damaged in the process of growing was compared with manually harvested grain which exhibited no visible damage in relation to the strike speed. Pea grains damaged in the course of growing - in relation to undamaged ones – have about a 6.7% lower germination capacity; this translates to 91.3%. With an increase in the speed of the striking, the germinating capacity decreased more markedly in the grain damaged in the course of growing (fig. 2). Approximate equations of the values measured as well as the approximate values and indices are presented for all figures in table1.

Table 1. Approximate equations of measured values, approximate constants and correlation indices

Fig.	No.	Type of approx. equation	Approximate constants B_0	B_1	B_2	Correlation index
2	1	PA	97.12	0.425	0.007	0.704
	2	PA	92.39	–1.176	–0.006	0.929
	3	EX	0.645	1.254	–	0.971
3	1	PA	97.51	0.789	–0.009	0.914
	2	EX	0.453	1.288	–	0.936
4	1	EX	97.98	0.993	–	0.834
	2	EX	0.578	1.268	–	0.929
5	1	PA	98.01	–0.746	0.006	0.927
	2	EX	0.505	1.274	–	0.904
6	–	PA	96.86	–0.594	–0.002	0.806
7		PA	95.92	0.294	–0.090	0.906
8	1	PA	96.43	0.546	–0.477	0.972
	2	EX	0.881	1.593	–	0.702
9	1	PA	76.31	11.88	–1.714	0.928
	2	PA	3.099	–1.092	0.357	0.898
10	1	PA	73.69	10.39	–1.542	0.640
	2	EX	1.608	1.458	–	0.952

Designation: PA – parabola $y = B_0 + B_1 x + B_2 x^2$; EX – exponential function $y = B_0 + B_1^x$.

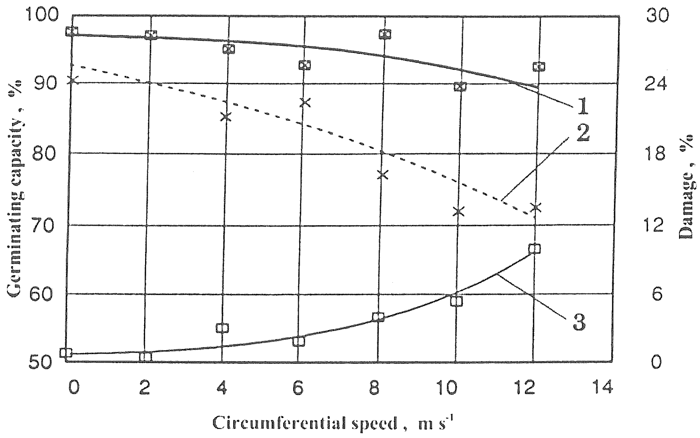

Fig. 2. The influence of the spinning jib's strike speed on the damage and germinating capacity of the pea grain – variety BELINDA – (moisture 9.7%). 1 – germinating capacity of undamaged grains, 2 – germinating capacity of grains damaged in the course of growing, 3 – damage of the entire grain

The increase in pea grain damage is directly in proportion to rising circumferential speed. A noticeable increase in damage is given at values above 6 m s^{-1}.

Damage occasioned in the course of growing the BELINDA variety of pea grain was 11.3% and occurred in the microphyl indicating that the seed's coat had been weakened, thereby impairing growth at the germination point. No increase in grain damage to that grain already damaged (in the course of growing) was observed in relation to rising circumferential speed.

The influence of the strike direction on the radicle, hilum and cotyledon of the grain indicated that the most noticeable decrease in the germinating capacity of the pea was for the strike direction on the radicle, where the germinating capacity of the grains decreased 11%, as opposed to 6.5% where the hilum was struck and by 7.6% where the cotyledon was struck. The intensity of the pea damage was approximately equivalent in all three directions and at a jib speed of 12 m s^{-1} the damage values were circa 10% (fig. 3, 4, 5).

The influence of the strike plate design on the damage and germinating capacity of grains was also observed (fig. 2, 6, 7).

The values measured indicate that the strike by the steel roller with the 2.7 mm diameter hemispheric head is quite different to the strike by either of the other strike plates viz. the plain strike plate and that with a diameter of 8 mm (fig. 2, 6, 7).

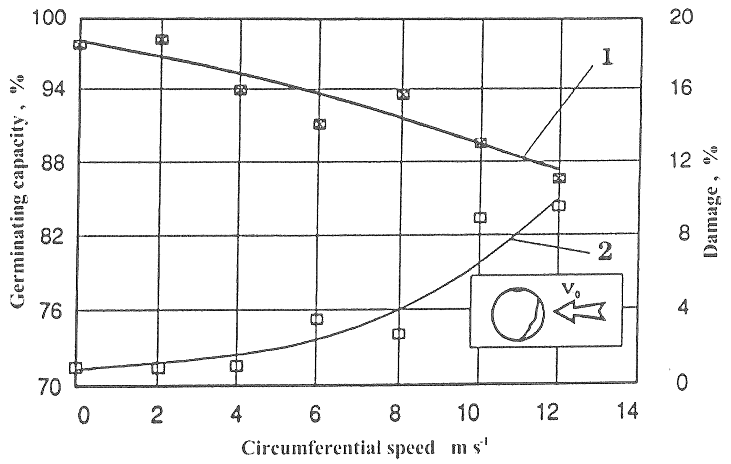

Fig. 3. The influence of the direction of the spinning jib strike on the damage and germinating capacity of the pea grain – variety BELINDA – striking the radicle (sprout), circumferential speed 12 m s^{-1}, moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to grains

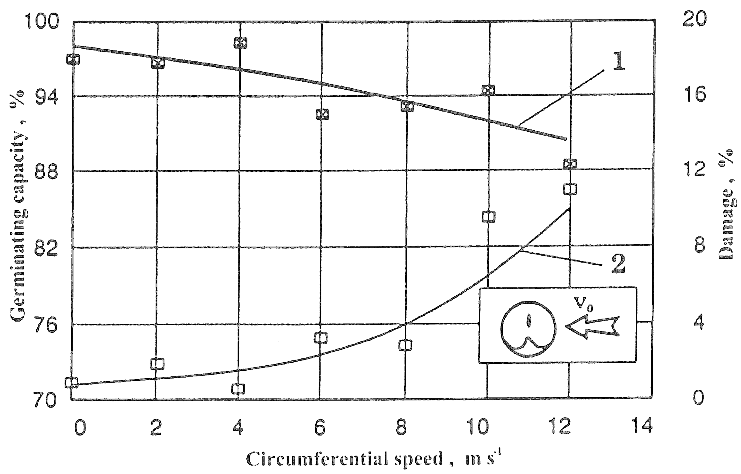

Fig. 4. The influence of the direction of the spinning jib strike on the damage and germinating capacity of the pea grain – variety BELINDA – striking the radicle (rootlet), circumferential speed 12 m s^{-1}, moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to the grains

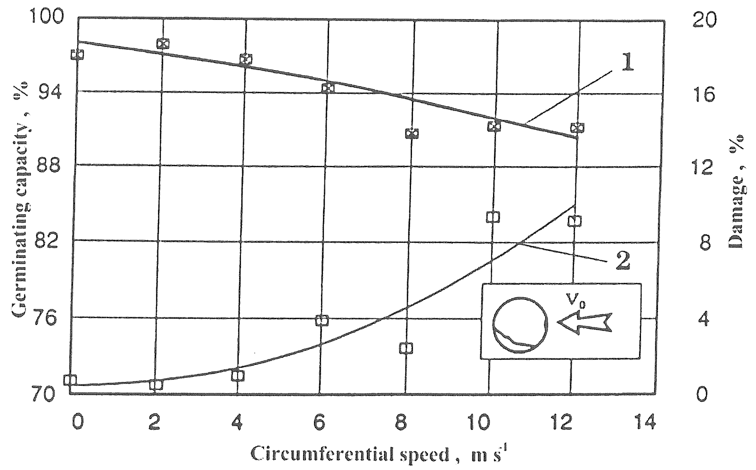

Fig. 5. The influence of the direction of the spinning jib strike on the damage and germinating capacity of the pea grain – variety BELINDA – striking the radicle (grain navel), circumferential speed 12 m s^{-1}, moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to the grains

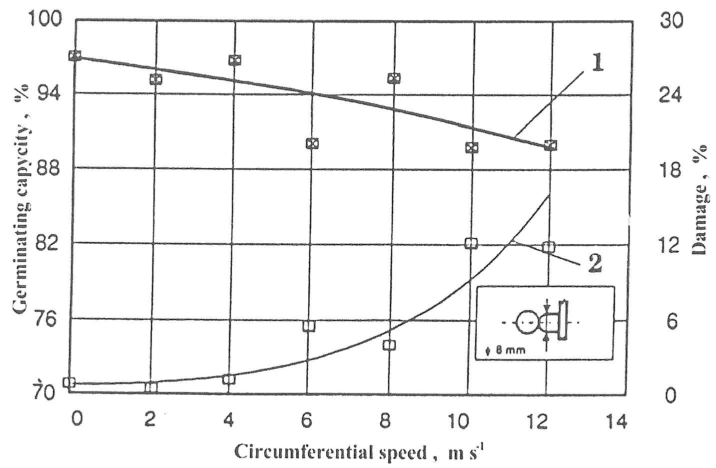

Fig. 6. The influence of the strike plate design of the spinning jib on the damage and germinating capacity of the pea grain – variety BELINDA – striking the steel roller with a hemispherical head, 8 mm in diameter, where: 1 – germinating capacity of grains, 2 – damage to the grains

It is evident from the figures presented that the increase in damage, – chiefly the decrease of the germinating capacity of the grain – occurred at a circumferential speed above 6 m s^{-1}. When the jib spun at a circumferential speed of 12 m s^{-1}, the germinating capacity decreased – in contradistinction to the original – by 3% and the grain damage increased by 2.6% (fig. 7).

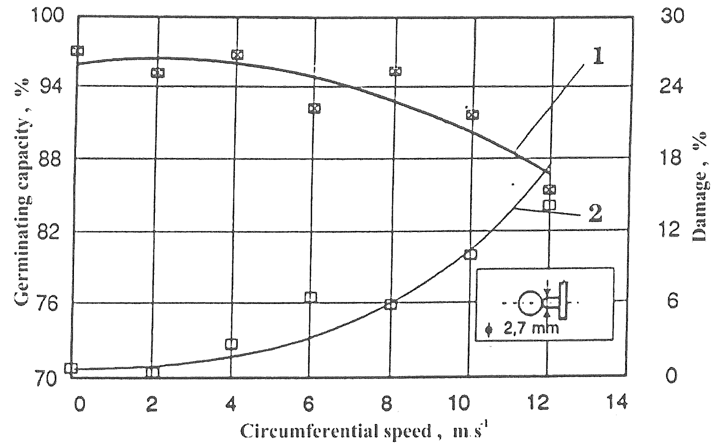

Fig. 7. The influence of the strike plate design of the spinning jib on the damage and germinating capacity of the pea grain – variety BELINDA – striking the steel roller with a hemispherical head, 2.7 mm in diameter, moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to the grains

A repeated number of strikes on the grain resulted in a decrease in the viability of the pea seed. The strike speed of the plain strike plate was measured as 10 m s^{-1}. After seven repeated strikes, the pea grains were destroyed and the germinating capacity of the grains decreased from the original 97% to 76% (fig. 8).

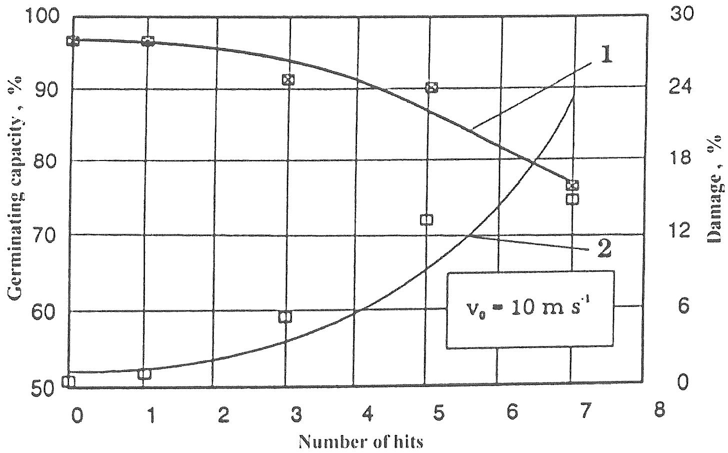

Fig. 8. The influence of repeated strikes on the pea grain – variety BELINDA – on the damage and germinating capacity, moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to the grains

The negative influence of repeated strikes on the grain was evident after the third consecutive strike at the circumferential speed of the spinning jib.

In terms of weight (size) – for quality appraisal purposes – the individual pea grains were divided into 5 weight categories. The effect of the intensity of the damage – occasioned in the course of growing – on the germinating capacity of the grains in the individual weight categories (fig. 9) was observed. Germinating capacity and damage to the pea occasioned during the growing process show that the best germinating capacity and damage values as above have grains of medium weight. The frequency was also highest in those grains observed.

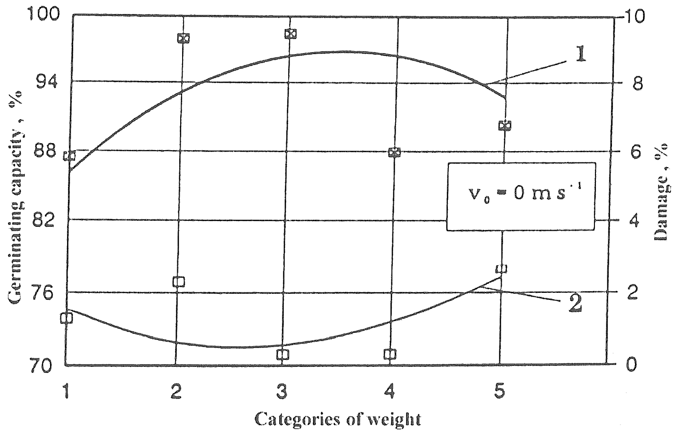

Fig. 9. The influence of pea grain weight of the variety BELINDA on the germinating capacity and intensity of damage occurring in the growing process, grain moisture 9.7%, where: 1 – germinating capacity of grains, 2 – contra damage to the grain

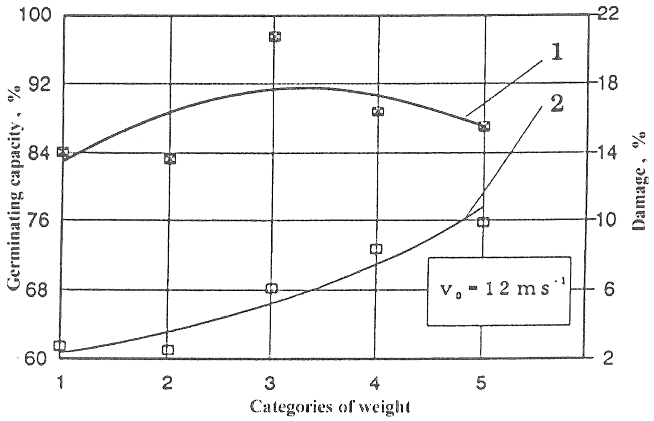

Fig. 10. The influence of pea grain weight – of the variety BELINDA – on the germinating capacity and damage intensity by the strike plate at a speed of 10 m s^{-1}, grain moisture 9.7%, where: 1 – germinating capacity of grains, 2 – damage to the grains

We exposed the same weight categories to being randomly struck at a speed of 12 m s^{-1} (fig. 10). Grain damage began to increase markedly with increasing weight and reached 10% at the highest weight category. The germinating capacity of the grain retained its previous tendency with a total decrease in germination capacity of 3-4%.

CONCLUSION

The measurements taken in the experiment result in the following conclusions:

1. Increasing the speed at which the grain is struck above 6 m s^{-1} at moisture 9.7% markedly increases grain damage and decreases germinating capacity.
2. Grains of medium weight were best for germinating capacity.
3. Grain damaged in the course of growing as opposed to undamaged grain have about a 6.7% lower germination capacity.
4. The direction of the strike on the cotyledon, the radicle or the plumule of the pea grain made no difference to the degree of damage; indeed the germinating capacity markedly decreased when the radicle was struck at a strike speed of 12 m s^{-1} in that the germinating capacity decreased by 11%.
5. The design of the strike plate has an influence on grain damage and germinating capacity.
6. The repeated striking of the grain at a speed of 10 m s^{-1} markedly prevents germinating capacity after the third strike. after the seventh strike the grain is destroyed.

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OBSERWACJE CHARAKTERYSTYK OBCIĄŻENIOWYCH NASION GROCHU

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Streszczenie. Przeanalizowano obciążenia dynamiczne nasion grochu o wilgotności 9,7%. Nasiona obciążano elementem udarowym o prędkości obwodowej w zakresie od 0 do 12 $m \cdot s^{-1}$. Analizowano wpływ tych obciążęń na uszkodzenia nasion, ich zdolność kiełkowania z uwzględnieniem masy poszczególnych nasion w zależności od miejsca przyłożenia obciążenia oraz konstrukcji elementu udarowego i jego reakcji. Testowano nasiona grochu w trakcie ich wzrostu. Stwierdzono, że ze wzrostem prędkości elementu udarowego na nasiona do 6 $m \cdot s^{-1}$ uszkodzenia znacząco wzrastały, zaś zdolność kiełkowania nasion obniżała się. Nasiona o średniej masie charakteryzowały się najwyższą zdolnością kiełkowania. Nasiona, które były uszkodzone wykazywały o około 6,7% mniejszą zdolność kiełkowania w stosunku do nasion nieuszkodzonych. Nie stwierdzono różnic w uszkodzeniach w zależności od miejsca przyłożenia obciążenia; od strony „znaczka", zarodka i liścieni, aczkolwiek konstrukcja elementu udarowego miała wpływ na uszkodzenia nasion.

Słowa kluczowe: dynamiczne obciążenia nasion grochu, uszkodzenia nasion, zdolność kiełkowania