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ATTEMPT TO DETERMINE BEAN-POD SUSCEPTIBILITY TO CRACKING

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A b s t r a c t. The paper presents a study of the effect of bean variety and pod shell moisture content on the susceptibility of bean pods to cracking. Research was conducted on four varieties of beans grown for dry seeds: Bor, Igołomska, Nida and Prosna at three levels of pod shell moisture content (11.9, 17.4 and 21.8%) using pressure method. Pods were filled with compressed air and the value of pressure at the moment of pod opening along their seams was measured.

Then a calculation of the values of total bursting force necessary for pod opening and specific force per 1 mm of pod seam was performed.

Statistical analysis showed a significant effect of bean variety and pod shell moisture content on the susceptibility of bean pods to cracking. Varying of pod moisture content over a range of 11.9 to 21.8 % caused an increase in the total pod bursting force which is necessary to open pods, from 29.01 to 102.54 N, and a rise in the specific bursting force from 0.28 to 0.87 N mm^{-1}. At the moisture content of 11.9 %, the tested varieties did not differ significantly in the susceptibility of their bean pods to cracking. However, significant differences appeared at higher levels of pod moisture content. Of the tested bean varieties, Igołomska and Bor exhibited the lowest susceptibility of bean pods to cracking while Nida and Prosna were most susceptible.

K e y w o r d s: bean-pod, susceptibility to cracking, pressure method

INTRODUCTION

An important problem in mechanical harvesting of French beans grown for dry seeds are losses from seed shedding and non-thrush. These losses depend on the harvesting method [8], structural features of working elements of harvesting machines: pickup reel, cutting unit, undercutter and threshing unit [1,2,8], as well as their working parameters: size of the work gap, tangential velocity of the threshing drum, throughput capacity, etc. [5].

Some unfavourable biological properties of bean plants have also a significant effect on seed loss. According to Jasińska [4], they include:

- susceptibility of pods to cracking,
- height of first pod base and number of pods per plant,
- susceptibility to lodging,
- non-uniform ripening of seeds and pods,
- high seed susceptibility to mechanical damage.

Susceptibility of bean pods to cracking determines the level of losses caused by seed shedding, i.e., easier cracking of pods leads to higher losses. Knowledge of the bean pods susceptibility to cracking, as well as its determining factors, may prove useful for the determination of harvest date, for construction of machines for bean harvesting and threshing and for defining correct operation parameters for those machines.

METHODS

The study was conducted on the pods of French beans: Bor, Igołomska, Nida and Prosna cultivars grown for dry seeds. The biometric characteristics of the studied cultivars is presented in Table 1. Susceptibility of bean pods to cracking was studied at three levels of pod-shell moisture content, i.e., 11.9, 17.4 and 21.8 %, using the pressure method developed by Szwed *et al*. [6]. A diagram of the test stand is presented in Fig. 1.

T a b l e 1. Pod characteristics (average values)

Variety	Length	Width (mm)	Thickness
Bor	98.2	6.9	7.1
Igołomska	112.4	8.3	8.6
Nida	94.8	10.7	9.8
Prosna	106.0	9.9	8.8

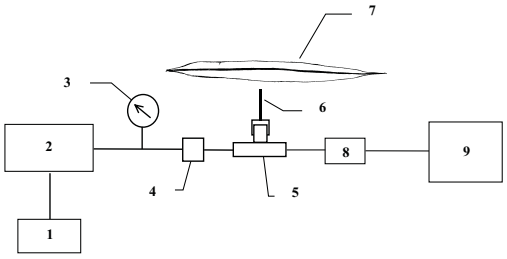

Fig. 1. Test stand: 1 - pump, 2 - compressed air bank, 3 - pressure gauge, 4 - cut-off-valve, 5 - T-tube, 6 - needle, 7 - pod, 8 - pressure sensor, 9 - computer.

In order to obtain suitable moisture contents, pods of individual varieties were moistened in a foil tunnel to the moisture content of about 25% and then left at room temperature until their moisture content was as required. Then random samples of 40 pods for each variety were taken. Prior to testing, each pod was measured (its length, width and thickness). In order to get air into the pod, a hole was made and a syringe needle was inserted into it. Teflon tape was used for sealing. The needle was wrapped before its insertion into bean pod. The needle was connected to a stub-pipe of a pipe-tee of air supply.

Once the cut-off valve was opened, compressed air flowing from the tank into the pod caused its opening along the seams joining both of its shells. The values of pressure inside the pod during filling and at the moment of opening were measured with a pressure gauge and recorded by a computer.

Approximate one part of the shell surface area of each tested pod was calculated from the formula:

$$S = l \cdot b \tag{1}$$

where: S - approximate one part of the pod shell surface area (mm^2), l - pod length (mm), b - pod width (mm).

This was followed by the calculation of the value of external bursting force: total - F_t (N) and specific - F_s (N mm^{-1}) per 1 mm of seam length, from the following formulas:

$$F_t = p\,S \tag{2}$$

where: F_t - total pod bursting force (N), p - pod bursting pressure (MPa), S - approximate one part pod shell surface area (mm^2), and:

$$F_s = F_t / l \tag{3}$$

where: F_s - specific pod bursting force (N mm^{-1}), l - pod length (mm).

The value of specific pod bursting force was assumed as a measure of pod susceptibility to cracking. The results obtained were processed statistically using analysis of variance at the significance level of $\alpha = 0.05$.

RESULTS

On the basis of the variance analysis (ANOVA), it was found that the moisture content of bean pod shells and bean cultivar had a significant effect on the magnitude of both total and specific pod bursting forces.

The value of those forces grew with the rising moisture content of bean pods for all the tested bean varieties, which means that the susceptibility of bean pods to cracking is higher for lower moisture contents (Fig. 2). However, the multiple range analysis showed that only for Bor and Igołomska bean varieties a significant increase in the total pod bursting force occurred for all the moisture levels, while a significant increase in the specific pod bursting force occurred for all the moisture levels only in the case of the Bor cultivar (Table 2).

At the first level of moisture content (11.9%), the values of an average total force necessary to open bean pods of the tested varieties did not differ to a statistically significant extent (Table 3 and Fig. 2a). A more pronounced differentiation among bean varieties in respect to the value of this force appeared only at higher levels

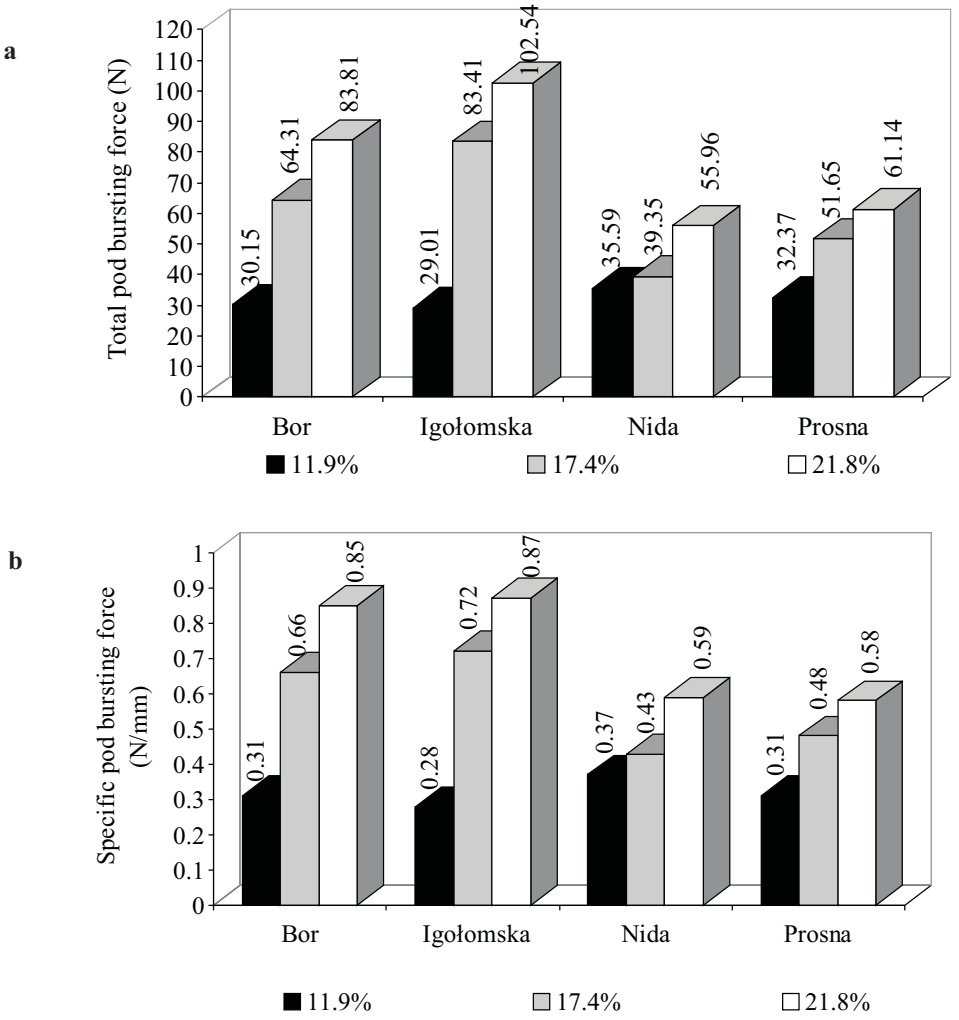

Fig. 2. Value of the total (a) and specific (b) bursting forces of different varieties of bean pods versus their moisture content.

of pod moisture content (17.4 and 21.8 %). Pods of the Nida cultivar exhibited the highest susceptibility to cracking (F_t = 55.96 N) while those of the Igołomska cultivar were most resistant (F_t = 102.54 N). A similar relationship exists for the specific pod bursting force, as reflected in Fig. 2b.

DISCUSSION

The dependence of the susceptibility of bean pods to cracking on their moisture content results from the pericarp structure, which inner surface (endocarp) consists of two parts built of thick-walled ligneous cells. As a result of different alignment of the micro-fibrils in the cell walls these two parts of endocarp shrink in different directions as they dry out, thus creating internal forces tending to open the pod [3]. That is why, the lower moisture content of pod shells, the higher internal forces and the lower external force necessary to open the pod.

It leads to the conclusion that differences in bean pods susceptibility to cracking result from their internal structure. As proved by

T a b l e 2. Multiple range analysis of the total pod bursting force F_t and the specific pod bursting force F_s by bean pod moisture content

Moisture content (%)	Variety							
	Bor		Igołomska		Nida		Prosna	
	Average	Homo-genous group	Average	Homo-genous group	Average	Homo-genous group	Average	Homo-genous group
	Total pod bursting force F_t (N)							
11.9	30.15	*	29.01	*	35.59	*	32.37	*
17.4	64.31	*	83.41	*	39.35	*	51.65	*
21.8	83.81	*	102.54	*	55.96	*	61.14	*
	Specific bursting force Fs (N mm^{-1})							
11.9	0.31	*	0.28	*	0.37	*	0.31	*
17.4	0.66	*	0.72	*	0.43	*	0.48	*
21.8	0.85	*	0.87	*	0.59	*	0.58	*

Horizontal distributions of symbols (*) show significant differences of mean values at α =0.05.

T a b l e 3. Multiple range analysis of the total pod bursting force F_t and the specific pod bursting force F_s by bean varieties

Variety	Moisture content (%)					
	11.9		17.4		21.8	
	Average	Homo-genous group	Average	Homo-genous group	Average	Homo-genous group
	Total pod bursting force F_t (N)					
Nida	35.59	*	39.35	*	55.96	*
Prosna	32.37	*	51.65	*	61.14	*
Bor	30.15	*	64.31	*	83.81	*
Igołomska	29.01	*	83.41	*	102.54	*
	Specific bursting force Fs (N mm^{-1})					
Nida	0.37	*	0.43	*	0.59	*
Prosna	0.31	*	0.48	*	0.58	*
Bor	0.31	*	0.66	*	0.85	*
Igołomska	0.28	*	0.72	*	0.87	*

Explanation as in Table 2.

Toma szewska [7] in her study on the anatomy of lupine pods, the pods which shells have thicker endocarp and thinner mesocarp (which consists of parenchyma cells) exibit higher tendency to cracking. In order to confirm that a similar relation exists for bean pods, it is necessary, among others, to perform measurements of endocarp and mesocarp of their shells.

CONCLUSIONS

1. Susceptibility of bean pods to cracking depends on their moisture content and cultivar characteristics.

2. Varying pod moisture content over a range from 11.9 to 21.8 % caused an increase in total pod bursting force (as necessary to open pods) from 29.01 to 102.54 N, and a rise in the

specific pod bursting force from 0.28 to 0.87 N mm^{-1}.

3. At the moisture content of 11.9%, the tested varieties did not differ significantly in the susceptibility of their bean pods to cracking. However, significant differences appeared at higher levels of pod moisture content.

4. Of all the tested bean varieties, Igołomska and Bor exhibited the lowest susceptibility of bean pods to cracking while Nida and Prosna were most susceptible.

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