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AN ATTEMPT AT MEASUREMENT OF THE AIR VOLUME IN BEAN PODS

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Summary. The study contains the results of preliminary tests on working out a method of fast measuring of the internal volume of a pod filled with the air. The tests were carried out on bean pods grown for dry seeds of cultivars: Narew, Nida and Warta. There was the comparison of four methods of measurement of the volume (pycnometric and three simple pod models). The four applied methods of volume measurement significantly influenced the results, both in the total volume of the pod and the air volume in the pod. The above mentioned qualities had higher results for the method II and lower for the method III. The volume measured with the method I (pycnometer) and the method IV differed statistically insignificantly. It can be claimed that the proposed in this method simple model of a pod enables to measure the total volume of a pod. Unfortunately, there is no elimination of the necessity of pyncometer measurements in order to calculate the air volume inside the pod.

Key words: bean pod, volume, measurement methods.

INTRODUCTION

While growing leguminous plants the important problem is, among others, the susceptibility of the pods to cracking and seeds release. Susceptibility of bean pods to cracking follows seeds release while harvesting as a result of acting harvesting machine apparatus, mainly cutting and trimming plants, cutter bars or harvesters [Furtak and Zaliwski 1986, Kuźniar and Sosnowski 2003a, Szot and Tys 1979].

The pod susceptibility to cracking is determined, among others, by the moisture content, pod shape, fiber content and structure in pod walls and seams, which in turn is significantly affected by meteorological conditions during plant vegetation period as well as the type and quantity of the applied fertilizers [Dorna and Duczmal 1994, Hejnowicz 1985, Kuźniar and Strobel 2000, Kuźniar and Sosnowski 2002, 2003b, 2006, Moś 1983, Tomaszewska 1954].

In order to define the influence of various factors on the susceptibility to cracking of fruits of this plant, it is necessary to create a method allowing to measure it precisely. One of the methods of evaluating the susceptibility to cracking is the pressure method [Kuźniar and Sosnowski 2000, Szwed *et al.* 1997, Szwed *et al.* 2000]. It relies on forcing into the pod, with injective needle,

compressed air and measuring the pressure at which stitches burst. The measure of susceptibility of the pods to cracking is the opening energy [Kuźniar and Sosnowski 2006, Strobel 2003] the measurement of which requires the knowledge of bursting pressure (relatively easy to measure) and also the air volume which is inside the pod. That second factor, due to irregular shape of such a fruit is difficult to measure. Strobel defines the air volume of the pod as the difference between the approximate volume of a pod and the volume of its seeds. The approximate volume of a pod is measured as a cylinder of the height equal to its length and the diameter being the arithmetic mean of width and thickness of a pod in its middle part.

The exact volume of a solid of irregular shapes may be measured by a pycnometer [Diehl *et al.* 1988], however, it is time consuming and requires relatively huge workforce as a result of the necessity of measurements concerning the whole pod, then its seeds and coat.

The aim of this study is to create a method for simplified measurement of the air volume inside a bean pod.

MATERIAL AND METHODS

The tests were conducted on the bean pods grown for dry seeds of cultivars: Narew, Nida and Warta which came from an experimental field of Department of Production Engineering of Rzeszow University. The characteristics of the pods of the tested pod varieties are presented in Table 1.

Table 1. Pod characteristics (average values) of tested bean cultivars

Specification	Narew	Nida	Warta
Dimension of pods [mm]			
Length	100,7	92,0	101,9
Width	9,2	9,7	9,0
Thickness	8,9	8,9	8,7
Number of seeds in a pod	4,6	4,4	5,2

The air volume of a pod was measured as the difference between the total volume of a pod and the volume of the inside seeds and the volume of its coats. The volume of the seeds and coats was measured with pycnometric method. The total volume of a pod was measured with four methods:

I. By means of pycnometer,
II. Measured as the volume of a cylinder of height equal to its length *l* and the section of ellipses of axis equal to the width and thickness of a pod in its middle part,
III. Measured as the volume of a solid consisting of:
   - Cylinder of 0.5 height equal to its length *l* and the section of ellipses as in the method 2,
   - Two cones of 0.25 *l* height
IV. Measured as the volume of a solid consisting of:
   - Cylinder of 0.75 height equal to its length *l* and the section of ellipses as in the method 2,
   - Two cones of 0.125 l height

The measurements were conducted on 20 pods of each variety, with the humidity of pods between 14.5 – 16%.

The given results underwent a statistical analysis.

RESULTS

On the basis of the analysis of variance, it was claimed that there is a significant influence of the bean variety and the methods of the pod, seed and coat volume measurement on the air volume inside the pod.

Table 2. The volume of pods, seeds and coats and the air in the tested pods of bean cultivars

Volume [cm3]:	Metoda	Narew	Nida	Warta
-total of a pod Vt	I	5.61 b	4.72 a	5.47 b
	II	6.48 a	6.22 a	6.33 a
	III	4.32 a	4.15 a	4.22 a
	IV	5.40 a	5.18 a	5.18 a
-of seeds in a pod Vs		0.73 a	0.71 a	0.71 a
-of pod coats Vc		1.04 a	1.05 a	1.80 b
-of the air in a pod V1 V1 = Vt Vs	I	4.88 b	4.00 a	4.76 b
	II	5.75 a	5.51 a	5.63 a
	III	3.59 a	3.43 a	3.52 a
	IV	4.67 a	4.47 a	4.57 a
-of the air in a pod V2 V2 = Vt Vs Vc	I	3.84 b	2.96 a	2.97 a
	II	4.71 b	4.46 b	3.83 a
	III	2.55 b	2.39 b	1.72 a
	IV	3.63 b	3.43 b	2.77 a

* different letters in a row signify significant differences, as per LSD test (significance level of α = 0.05)

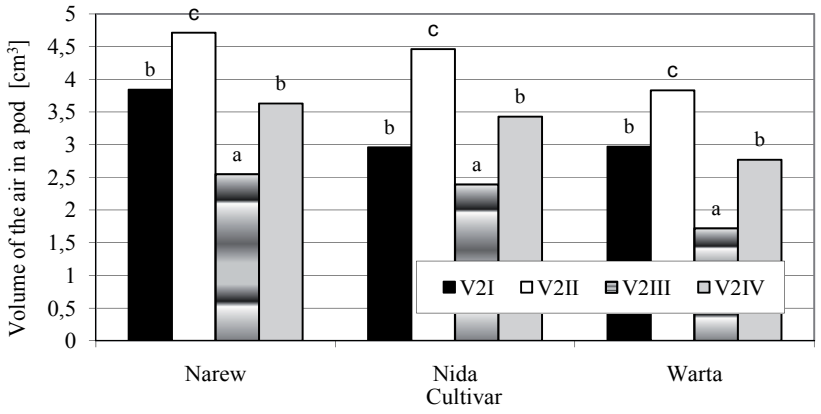

Fig. 1. The differentiation of the air volume (*V2*) in bean pods measured by various methods (I-IV). Different letters signify significant differences, as per LSD test (significance level of α = 0.05)

The analysis carried out by means of LSD test (Table 2) showed that considering the total volume of a pod V_t only in the method I, in which the tested varieties were statistically significantly different among themselves, the pods were never significantly smaller. Exactly the same differentiation was visible between the varieties for the air volume in a pod V_l gained after the subtraction of the seed volume V_s from the total pod capacity, as a result of the lack of significant differences in the sizes of the seeds of the tested bean varieties. However, considering, as well, the coat volume V_c while measuring the air capacity inside a pod (V_2) caused greater differentiation between the tested varieties. Warta pods, due to their characteristics, significantly differed from the other three methods, had significantly lower air volume than the Narew pods for the method I. While measuring with a pyncometer the air volume in a pod needed for measuring the pod opening energy, not only the seed volume should be considered but also the coat volume.

On the basis of the given results in Table 2 and in Figure 1, it should be claimed that these four methods of measuring the volume significantly influenced the scope of the given results, both for the total pod volume V_t and for the air volume in a pod V_1 and V_2. The above-mentioned qualities had higher results for the method II and lower for the method III. The volume measured with the method I (pycnometer) and the method IV differed statistically insignificantly. It can be claimed that, proposed in this method, a simple model of a pod enables to measure the total volume of a pod. Unfortunately, there is no elimination of the necessity of pyncometer measurements in order to calculate the air volume inside the pod.

CONCLUSIONS

1. The size of the air volume inside the pod relied statistically significantly on a variety and the method of its measurement.
2. The method I (pycnometric) was the most detailed out of the applied ones.
3. The volumes: the whole one of the pod and the one of the air inside, measured with the method II were significantly overstated in comparison to the ones measured with the method I while the ones measured with the method III were lowered.
4. The volume measured with the method IV did not differ statistically significantly from that measured with the method I.
5. Unfortunately, the method IV does not eliminate the necessity of pyncometer measurements in order to calculate the air volume inside the pod.

REFERENCES

Diehl K.C., Garwood V.A., Haugh C.G. 1988: Volume measurement using the air-comparison pycnometer Trans. ASAE, 1, 284-287.

Dorna H., Duczmal K. W. 1994: Wpływ warunków klimatycznych na formowanie włókna w szwach strąków fasoli zwykłej (*Phaseolus vulgaris* L.). I Ogóln. Konf. Nak. Strączkowe Rośliny Białkowe. FASOLA, Lublin 25.11.1994, 135-138.

Furtak J., Zaliwski A. 1986: Badania nad zbiorem mechanicznym nasion fasoli. Roczniki. Nauk Roln, ser. Technika Rolnicza, 2, 127-140.

Hejnowicz Z. 1985: Anatomia i histogeneza roślin naczyniowych. PWN, Warszawa.

Kuźniar P., Strobel W. 2000: Określenie wpływu grubości sklerenchymy strąków fasoli na ich podatność na pękanie. Acta Agrophysica, 37, 113-117.

Kuźniar P., Sosnowski S. 2000: Attempt to determine bean-pod susceptibility to cracking. International Agrophysics, 14, 197-201.

Kuźniar P., Sosnowski S. 2002: Relation between the bean pod shape factor and force required for pod opening. International Agrophysics, 16(2), 129-132.

Kuźniar P., Sosnowski S. 2003a: Podatność strąków na pękanie a wielkość strat nasion fasoli podczas mechanicznego zbioru. Acta Agrophysica, 2(1), 113-118.

Kuźniar P., Sosnowski S. 2003b: Wpływ wilgotności strąków fasoli i ich wielokrotnego nawilżania na siłę potrzebną do ich otwarcia. Acta Agrophysica, 2(1), 119-126.

Kuźniar P., Sosnowski S. 2006: Energy necessary to open bean pods in various nitrogen fertilization levels. TEKA Commission of Motorization and Power Industry in Agriculture. VI A, 123-127.

Moś M. 1983. Zmienność morfologicznych i anatomicznych cech strąka, jej wpływ na skłonność do pękania i plon nasion komonicy zwyczajnej (*Lotus corniculatus* L). Zesz. Probl. Post. Nauk Roln., 258, 197-203.

Strobel W. 2003: Porównanie cech fizycznych strąków różnych gatunków łubinu. Zeszyty Problemowe Postępów Nauk Rolniczych, 495, 73-80.

Szot B., Tys J. 1979: Przyczyny osypywania się nasion roślin oleistych i strączkowych oraz metody oceny tego zjawiska. Problemy Agrofizyki, 29.

Szwed G., Strobel W., Tys J. 1997: Mechanizmy rządzące procesami pękania strąków łubinu. Mat. Konf. Łubin we współczesnym rolnictwie, Olsztyn 25-27.06.1997,107-112.

Szwed G., Tys J., Strobel W. 2000: Pressurized methods for grading the vulnerability of pods splitting. International Agrophysics, 13, 391-395.

Tomaszewska Z. 1954: Wstępne badania nad anatomią strąków łubinu. Acta Agrobotanica, 2, 151-171.