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Energy of bean pods opening with phosphorous fertilization

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S u m m a r y. The study encompasses the results of research on a phosphorous fertilization impact on the energy necessary to open bean pods cultivated on dry seeds of varieties: Narew, Nida and Wawelska carried out in the years 2008-2010. Four doses of phosphorous were used: 0, 40, 80 and 120 kg·ha^{-1}. Nida variety was characterized with pods most vulnerable to cracking (opening energy 169.3 mJ), and pods least vulnerable to cracking were found in Narew variety (opening energy 262.5 mJ). Increasing phosphorous dose from 0 to 120 kg·ha^{-1} caused a decrease in the amount of energy necessary to open pods of the tested bean varieties, except for Wawelska variety, where an insignificant increase of this energy was observed.

K e y w o r d s: bean pod, opening energy, phosphorous fertilization.

INTRODUCTION

The main unfavourable feature of oil and leguminous plants is the tendency to crack their siliques and pods and flake their seeds before and after harvesting [5, 9, 14, 15]. Vulnerability of pods to cracking is a variety feature and is mainly determined by their structure and shape in cross section [7, 17, 18]. Among the elements of pod internal structure, their vulnerability to cracking is determined by, among others, content and structure of fibre in walls of their shells and seams which are considerably influenced by meteorological conditions in the period of growth as well as type and amount of the used fertilizers [3, 4, 6, 8, 10, 13, 19, 20].

The aim of this study was to evaluate an impact of diverse phosphorous fertilization on the amount of energy necessary to open pods of bean varieties cultivated on dry seeds.

MATERIAL AND METHODS

The research was conducted in 2008-2010. The bean was cultivated on the experimental field of the Department of the Farm and Food Production Engineering in Rzeszów. Four phosphorous doses were applied before sowing: 0, 40, 80, 120 kg·ha^{-1}. The tested bean varieties were characterized with a diverse size of seeds and pods (Tab. 1).

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

Specification	Narew	Nida	Warta	Wawelska
Dimension of pods [mm]:				
Length	93,0	89,5	103,7	112,3
Width	10,1	10,4	10,0	11,2
Thickness	9,3	9,1	8,9	9,8
Number of seeds in pod	4,6	4,0	4,3	3,7

Energy required to open a pod was calculated with the pressure method [11, 16, 18] which is based on tearing a pod by compressed air (Fig. 1) from the relation:

$$E = \frac{3}{2} pV, \tag{1}$$

where:
E - energy of bean pods opening [J],
p - air pressure in the pod [Pa],
V - air volume inside the pod [m^3].

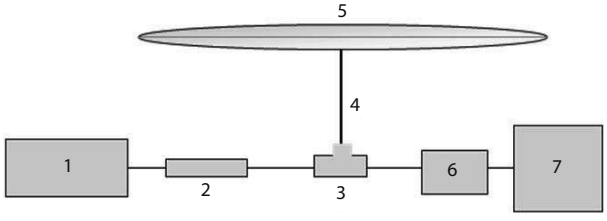

Fig. 1. Total device: 1 – compressed air bank, 2 – pressure gauge and cut-off-valve, 3 – T-tube, 4 – needle, 5 – pod, 6 – pressure sensor, 7 – computer

Air volume in a pod was determined with modified pictometric method [2, 11, 12].

Measurements were carried out on 20 pods for each variety with humidity in the range of 12.4-13.8%. The obtained results were statistically analyzed [1] with Statistica 9 program, with which variance analysis and LSD significance test were conducted.

RESULTS

Nida variety was the most vulnerable to cracking pods (Fig. 2). The statistically smallest amount of energy was necessary to open its pods, on average 169,3 mJ. The pods most resistant to cracking were found in Wawelska and Narew varieties for which opening energy amounted to 262.5 and 244.9 mJ, respectively.

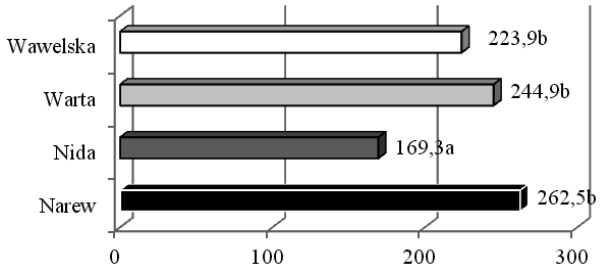

Fig. 2. Average from three years energy of pods opening [mJ] of tested bean varieties

*different letters signify significant differences for the significance level α = 0.05

The value of opening energy of bean pods of the tested varieties from years 2008-2010 for applied doses was presented in Table 2.

When analyzing the results contained in Table 2, it should be noted that pod opening energy of the tested varieties was diverse and depended on phosphorous dose and years. In case of Nida variety, changes of opening energy with the increase of phosphorous dose were not statistically important in any year of the research, whereas for Warta they were significant in 2009, and for Wawelska in 2009 and 2010. Only in case of Narew variety, significant changes in opening energy were observed in all the three years of research.

The pods were characterized with the lowest vulnerability in 2008. Narew and Nida pods were most prone to cracking in 2010, while Warta and Wawelska in 2010. A decrease of energy required to open pods of the tested bean varieties with the increase of phosphorous dose was observed (Tab. 2), with the exception of Wawelska which displayed a very slight increase of the amount in question.

The relation of pod opening energy of the tested bean varieties with phosphorous dose is well described by linear function (Fig. 3) in the form of:

$$E = a \cdot D + b, \tag{2}$$

where:
a, b - coefficients of equation,
D – phosphorous dose [kg·ha^{-1}].

Fig. 3. Relation of the pod opening energy of tested bean varieties to the dose of phosphorous

Coefficients of equations describing the relation of pod opening energy of the tested bean varieties with the phosphorous doses and their determination coefficients were presented in Table 3.

Table 2. Energy of pod opening [mJ] on tested bean varieties for applied doses of phosphorous

Variety	Years	Phosphorous doses [kg·ha^{-1}]				Average
		0	40	80	120	
Narew	2008 2009 2010	316,1ab 324,7b 345,0b	284,1b 284,6ab 112,9a	441,3b 256,9ab 177,2a	291,8a 181,8a 133,7a	333,3 III 262,0 II 192,2 I
	Average	328,6c	227,2ab	291,8bc	202,4a	262,5
Nida	2008 2009 2010	220,6a 203,8a 122,8a	193,8a 143,6a 126,1a	213,6a 169,4a 131,2a	273,0a 126,4a 107,3a	225,3 II 160,8 I-II 121,8 I
	Average	182,5a	154,5a	171,4a	168,9a	169,3
Warta	2008 2009 2010	185,1a 218,6a 290,1b	381,2b 202,4a 293,9b	332,2b 144,8a 201,3ab	361,2b 167,1a 162,2b	314,9 II 183,2 I 236,8 I
	Average	231,3a	292,5a	226,1a	230,2a	245,0
Wawelska	2008 2009 2010	259,7ab 205,5a 230,9a	204,4a 156,7a 185,9a	380,7b 189,9a 232,2a	357,4b 96,7a 187,8a	300,5 II 162,2 I 209,2 I
	Average	232,0ab	182,3a	267,6b	214,0b	224,0

*different letters in row and Roman numerals in column signify significant differences for the significance level α = 0.05

Coefficients of the analyzed equations indicate that the largest decrease of resistance to pod cracking with the increase of phosphorous dose occurred for Narew variety for which the increase of phosphorous dose of 1kg·ha^{-1} caused a decrease of 0.78 mJ of the energy necessary to open them.

Table 3. Values of coefficients of determination R^2 and coefficients of equation $E = a \cdot D + b$, describing dependence of opening energy of pods E on applied doses of phosphorous D

Variety	a	b	R^2
Narew	-0,7851	309,62	0,4888
Nida	-0,0597	172,90	0,0718
Warta	-0,1742	255,44	0,0804
Wawelska	0,0778	219,31	0,0127
Average	-0,2353	239,32	0,3979

Tomaszewska [19, 20] showed in her research that pods in the shells of which fibre layer consisted of sclerenchymatic cells is thicker or these cells are stronger, are more prone to cracking since during their drying larger stresses occur in the shell aiming at the pod opening. An increase of bean pod cracking vulnerability of the tested varieties with the increase of nitrogen dose may prove that there was an increase in thickness of shell fibre layer or strengthening of the structure of sclerenchymatic cells.

CONCLUSIONS

Pod opening energy of the tested bean varieties was diverse and depended on the used phosphorous doses.

Pods of Nida variety were most vulnerable to cracking. The energy in the mean amount of 169.3 mJ was sufficient to open them. Narew variety had pods most resistant to cracking, for them the opening energy amounted on average to 262.5mJ.

An increase of phosphorous dose from 0 to 120 kg·ha^{-1} caused a decrease in the amount of energy necessary to open pods of the tested bean varieties with the exception of Wawelska variety for which a statistically irrelevant increase of opening energy was observed.

Relation of the mean three year pod opening energy of the tested bean varieties with the applied phosphorous doses is described by linear function.

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ENERGIA OTWARCIA STRĄKÓW FASOLI
PRZY ZRÓŻNICOWANYM NAWOŻENIU FOSFOROWYM

S t r e s z c z e n i e . Praca zawiera wyniki badań wpływu nawożenia fosforowego na energię potrzebną do otwarcia strąków fasoli uprawianej na suche nasiona odmian Narew, Nida, Warta i Wawelska wykonane w latach 2008-2010. Zastosowano cztery dawki fosforu: 0, 40, 80 i 120 kg·ha^{-1}. Najbardziej podatnymi na pękanie strąkami charakteryzowała się odmiana Nida (energia otwarcia 169,3 mJ), a najmniej podatne na pękanie strąki odnotowano u odmiany Narew (energia otwarcia 262,5 mJ). Zwiększenie dawki fosforu od 0 do 120 kg·ha^{-1} spowodowało spadek wartości energii potrzebnej do otwarcia strąków badanych odmian fasoli za wyjątkiem odmiany Wawelska, dla której odnotowano nieistotny wzrost tej energii.

S ł o w a k l u c z o w e : strąk fasoli, energia otwarcia, nawożenie fosforowe.