TEKA Kom. Mot. Energ. Roln., 2006, 6A, 123–127

ENERGY NECESSARY TO OPEN BEAN PODS AT VARIOUS NITROGEN FERTILIZATION LEVELS

Piotr Kuźniar, Stanisław Sosnowski

Department of Production Engineering, University of Rzeszów
M. Ćwiklińskiej Str. 2, 35-601 Rzeszów, Poland,
e-mail: ssos@univ.rzeszszov.pl

Summary. A study of the effect of nitrogen fertilization of bean crop on the value of energy needed to open its pods. Testing performed on pods of beans of Narew, Nida and Warta cultivars grown for dry seeds, with nitrogen fertilizers applied in doses of 0, 30, 60 and 90 kg·ha^{-1} prior to sowing. The susceptibility of bean pods to cracking was determined by pressure method. The pod opening energy for the tested bean cultivars varied and depended on the applied dosage of nitrogen fertilizers. Pods of Nida bean cultivar appeared to be the most susceptible to cracking. An average energy of 0.88 J was sufficient to open them. Pods of Narew bean cultivar appeared to be the most resistant to cracking, as their opening energy averaged at 2.35 J. Raising the dosage of nitrogen fertilizers from 0 to 90 kg·ha^{-1} led do a decrease in the value of energy needed to open pods of all the tested bean cultivars. Such a decrease was not statistically significant for Warta cultivar only. The relationship between pod opening energy and the dosage of nitrogen fertilizers had a form of linear function.

Key words: bean pod, energy of pod opening, nitrogen fertilizer dosage

INTRODUCTION

One of the major problems in cultivation of leguminous plants is the pod susceptibility to cracking and shedding the seeds prior to and during harvest, with quite significant consequential losses. Self-opening of pods occurs in the majority of narrow-leaf lupine cultivars [Szot and Tys 1979, Szwed *et al*. 1997, 2000, Strobel 2003] and significantly less in case of beans cultivated for dry seeds. This susceptibility of beans to burst cracking manifest itself with seed shedding during harvest as a result of action of working units of harvesting machines, mainly various devices for plant cutting or undercutting, reels and pick-ups [Furtak and Zaliwski 1986, Kuźniar and Sosnowski 2003].

In order to define suitable design and operating parameters of machines for bean harvesting, as well as correct harvesting time, it is important to learn about factors that determine the susceptibility of the fruit of that plant to burst cracking [Szot and Tys 1979, Kuźniar and Sosnowski 200]

The pod susceptibility to cracking is determined, among others, by the fiber content and structure in pod walls and seams, which in turn is significantly affected by meteoro-

logical conditions during plant vegetation period as well as the type and quantity of the applied fertilizers [Korohoda 1969, Hejnowicz 1985, Woyke and Gabryl 1987, Dorna, Duczmal 1994].

The purpose of this research was to assess the effect of varied nitrogen fertilization on the level of energy needed to open bean pods. Nitrogen fertilizers were applied just once, prior to sowing, in doses of 0, 30, 60 and 90 $kg \cdot ha^{-1}$ (as pure ingredient).

MATERIAL AND METHODS

The tests were carried out on pods of beans grown for dry seeds, Narew, Nida and Warta cultivars, which came from the experimental field of the Production Engineering Department of the Rzeszow University. Refer to Table 1 for the characteristics of the tested pods of bean cultivars.

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

Specification	Narew	Nida	Warta
Dimension of pods, mm:			
Length	108.3	87.5	90.9
Width	9.2	9.2	10.0
Thickness	8.3	8.3	8.8
Number of seeds in a pod	4.7	4.0	4.5

The pod susceptibility to burst cracking is determined by the pressure method [Szwed *et al.* 1997, 2000, Kuźniar and Sosnowski 2000, Strobel 2003]. It consists in pressing compressed air into a pod through a special needle and measuring the level of pressure at which the pod seams become torn apart. The diagram of the measuring stand is presented in Fig. 1.

An extensometric pressure sensor, coupled with a computer through a measuring desk, was applied for the measuring of incremental pressure flowing into the tested pods. The 'IP-Coach 4.0' software program, installed in the computer, enabled the recording of pressure curve in the course of pod filling and reading its value.

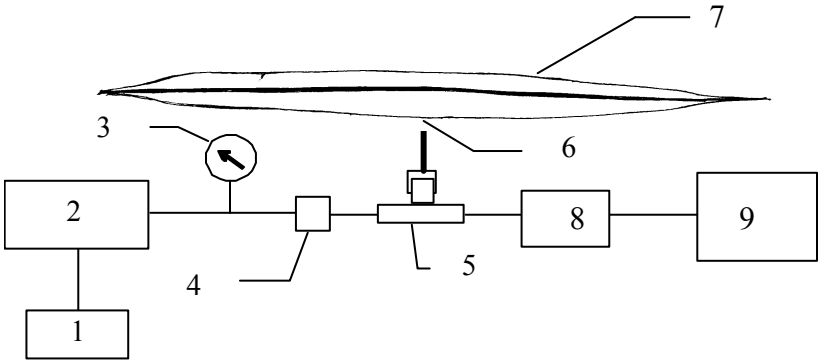

Fig.1. Total device: 1 – pump, 2 – compressed air bank, 3 – pressure gauge, 4 – cut-off-valve, 5 – T-tube, 6 – needle, 7 – pod, 8 – pressure sensor, 9 – computer

The pod opening energy was calculated from the formula [Strobel 2003]:

$$E = \frac{3}{2} pV$$

where:

E – pod opening energy, J,
p – air pressure in the pod at the moment of its burst cracking, Pa,
V – approximate pod volume, m^3.

The approximate pod volume was calculated as the volume of a cylinder, with its height equal to its length and elliptic cross section with axes equal to pod width and thickness in its middle part, from which the volume of pod seeds was deduced. The seed volume was calculated as the product of seed number in the pod and the mean volume of seed determined with pycnometer.

The measurements of bursting pressure were carried out on 30 pods for each variant, with the pod moisture within the range of 14,5–16%.

The obtained results were statistically processed.

RESULTS

On the basis of ANOVA, it was found that bean cultivar and nitrogen doses had a significant effect on the value of energy necessary for pod bursting. On the basis of the obtained results, as presented in Table 2, the pods of the Nida cultivar exhibited the highest susceptibility to burst cracking, as they required mean opening energy of only 0.88 J. The lowest susceptibility to burst cracking was shown by pods of the Narew cultivar, which cracked at mean energy of 2.35 J.

The analysis of significance of differences using the NIR test (Tab. 2) showed that all the tested varieties differed significantly in respect to their mean value of energy necessary for bursting their pods. However, in the analysis of the value of bursting energy for the tested varieties, with various levels of fertilization, the observations showed no significant differences, in respect to that parameter, between Nida and Warta cultivars for the first three doses, and no significant differences between Narew and Warta cultivars for the fourth dose of the fertilizer.

Table 2. Energy of pod opening, J

Cultivar	Nitrogen fertilizer dose, kg·ha^{-1}				Average A
	0	30	60	90	
Narew	3.41c	2.40b	2.36b	1.22a	2.35c
Nida	1.23b	0.83ab	0.83ab	0.62a	0.88a
Warta	1.73a	1.32a	1.35a	1.42a	1.46b
Average B	2.13c	1.52b	1.51b	1.09a	

a,b,c – different letters signify significant differences, as per LSD test.

The obtained research results (Tab. 2, Fig. 2) indicate that the pod opening energy for Narew and Nida cultivars became reduced with growing quantity of applied nitrogen

from 0 to 90 kg·ha^{-1} by approx. 64% and 50%, respectively. The Nida variety showed the lowest value of pod opening energy at the dose of 30 kg·ha^{-1}. Further raising of nitrogen quantity raised this energy insignificantly, so that, at the dose of 90 kg·ha^{-1} pods were opened with the energy lower than that at zero dose, i.e. they continued to be more susceptible to burst cracking.

The relationship of pod opening energy on the dose of nitrogen fertilizers was of linear function character (Fig. 2). The fertilization had the highest effect on rising susceptibility of pods to burst cracking for the Narew cultivar and the lowest effect on that characteristic for the Warta cultivar. Raising the nitrogen dose in those cultivars by 1 kg resulted in the mean reduction of the energy needed for pod opening by 0.022 J and 0.0061 J, respectively.

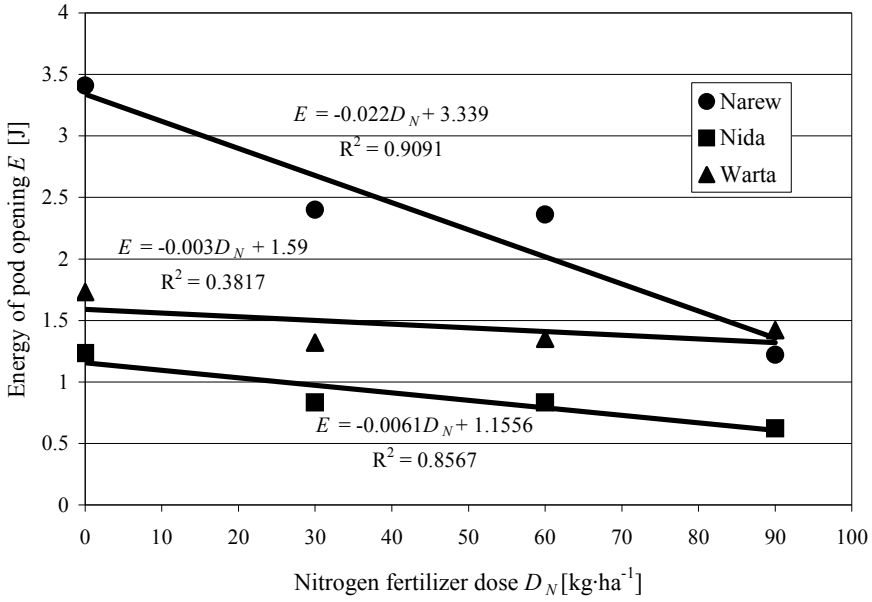

Fig. 2. Energy of pods opening (E) versus nitrogen fertilizer dose (D_N)

CONCLUSIONS

1. The pod opening energy for the studied bean cultivars differed, and it depended on the dose of the applied nitrogen fertilizers.
2. The Nida cultivar appeared to have pods most susceptible to burst cracking. The mean energy of 0.88 J was sufficient to open them. The Narew cultivar had pods most resistant to burst cracking, as their opening energy averaged at 2.35 J.
3. Raising of the dose of nitrogen fertilizers from 0 to 90 kg·ha^{-1} caused a reduction in the value of energy needed to open pods of all the studied bean cultivars. That reduction was not statistically significant for the Warta cultivar only.

4. The dependence of pod opening energy on the dose of nitrogen fertilizers had a character of linear function.

REFERENCES

Dorna H., Duczmal K. W. 1994: Wpływ warunków klimatycznych na formowanie włókna w szwach strąków fasoli zwykłej (*Phaseolus vulgaris* L.). I Ogóln. Konf. Nauk. „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. Tech. Roln., 2, 127–140.

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

Korohoda J. 1969: Fasola. PWRiL, Warszawa.

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

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

Strobel W. 2003: Porównanie cech fizycznych strąków różnych gatunków łubinu. Zesz. Probl. Post. Nauk Roln., 495, 73–80.

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

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

Szwed G., Tys J., Strobel W. 2000: Pressurized methods for grading the vulnerability of pods splitting. Int. Agrophysics, 13, 391–395, 1999

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

Woyke H., Gabryl J. 1987: Warzywa strączkowe. PWRiL, Warszawa.