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EFFECT OF DYNAMIC LOADING ON THE QUALITY OF SOYBEAN

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A b s t r a c t. The paper presents a research study on the effects of soybean seed impacting by a rotating steel arm of circumferential speed 21.46 ms^{-1}. Three varieties of soybean (Aldana, Polan and Progres) were tested in relation to their moisture content variations. The sample seeds were evaluated in respect of the resulting mechanical damage, as well as the value of seed energy and capability of germination. On the basis of the results, it was found that the varieties differed greatly in their seed susceptibility to mechanical damage but only in the low moisture content range of 7 - 14 %. The optimum moisture content, at which the damage was below 5 % for specific varieties, varied from variety to variety (13.1 % for Aldana, 18.5 % for Polan and 15.3 % for Progres). As the extent of mechanical damage increased, the seed energy and capability of germination decreased. The seeds disqualified in the germination test consisted mainly of seeds which germinated abnormally, especially in the low moisture content range.

K e y w o r d s: soybeans, mechanical damage, moisture content, capability of germination

INTRODUCTION

During threshing and drying soybean seeds suffer significant mechanical damage [1,3,4], especially in the threshing stage when the seeds undergo numerous impacts against steel elements of threshing units. The consequences of those impacts are broken seed, seed cover cracks, as well as the invisible internal damage. The extent and structure of threshing damage depends not only on the design characteristics of the threshing unit and its operating parameters, but also on threshing conditions and cultivar characteristics of the tested plant.

The seed moisture content is one of the basic parameters of a threshed plant which determines the extent of suffered damage [5,7]. Knowledge of optimum seed moisture content ranges would enable losses suffered during threshing to be minimised. The most often quoted cultivar characteristics of seeds are their dimensions and shape, seed mass, and thickness of seed cover, etc. [2,5].

Having that in mind, a research study was undertaken to evaluate of the effect of dynamic loading of individual seeds of various soybean cultivars on the resulting mechanical damage related to seed moisture content. The effects of those loadings on the variation of seed energy and capability of germination were also determined.

METHODS

The research consisted in determining the consequences of dynamic loading of seeds through evaluation of resulting mechanical damage and a change in sowing (seeding) value. Individual seeds were impacted by a rotating steel arm (Fig. 1) having a circumferential speed of 21.46 ms^{-1}. The seeds subjected

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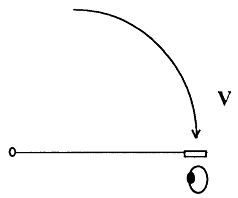

Fig. 1. Seed loading mode. V - speed.

to such loads were evaluated in respect of the resulting mechanical damage, as well as the variation of seed energy and capability of germination. In the damage structure those seeds with missing portions and those with cracked seed cover were selected out. Additionally, at the sowing value evaluation stage, dead, abnormally germinating and sound but not germinating seeds were isolated. The seed germination test was carried out on a sand bed at a temperature of 20/30°C. The sample size was 4 x 100 seeds. In order to obtain proper levels of seed moisture content whole pods were moistened in a chamber with a controlled atmosphere and then, during free drying time at 20°C, samples for measurements were taken at suitable intervals. Samples of 200 seed sizes were subjected to loading in 4 repetitions. Three variations of soybean seeds were measured at 5 moisture content levels:

- Aldana: 7.1-20.3% (7.1, 11.5, 14.4, 16.3, 20.3%),
- Polan: 7.9-19.9% (7.9, 12.5, 14.6, 16.7, 19.9%),
- Progres: 6.7 - 20.0 % (6.7, 12.5 , 14.8 , 17.2 , 20.0 %).

The results were evaluated statistically.

RESULTS

Characteristics of the tested material

The seeds were from the Experimental Plant Growing and Acclimatisation Station in Ożańsk, Jankowce Branch. The tested varieties were cultivated in similar conditions with similar agrotechnical procedures applied. For testing the entire plants were removed manually at a fully mature stage and seeds were sampled from them.

While comparing average dimensions of seeds of tested varieties (Table 1) it should be said that the Aldana variety had the longest and thickest seeds. A dimensional homogeneity test (Table 2) proved that each variety constituted a separate group only in seed length. In respect to other dimensions there were no clear differences in compared characteristics. In width terms there was no perceptible difference between Polan, and Aldana and in thickness terms there was no difference between Progres and Polan, as well as between Polan, and Aldana varieties. In the respect of 1000 seed mass, the Progres variety differed also from the other two varieties which constituted a homogenous group (Table 2). Thus, the Progres variety was characterised by the smallest mass of 1000 seeds (166 g) while the

Table 1. Seed characteristics (average values)

Variety	Seed length (mm)	Seed width (mm)	Seed thicness (mm)	Mass of 1000 seeds (g)
Aldana	8.18	6.86	5.43	173
Polan	6.07	6.89	5.22	176
Progres	7.01	7.78	5.12	166

Table 2. Multiple range analysis of seeds dimension and mass of 1000 seeds between varieties

Method: Level	95 % Count	Confidence Average	Intervals Homogeneous groups
	Seed length (mm)		
2. Polan	5	6.072	*
3. Progres	5	7.012	*
1. Aldana	5	8.182	*
	Seed width (mm)		
2. Polan	5	6.858	*
1. Aldana	5	6.860	*
3. Progres	5	7.880	*
	Seed thickness (mm)		
3. Progres	5	5.124	*
2. Polan	5	5.218	**
1. Aldana	5	5.430	*
	Mass of 1000 seeds (g)		
3. Progres	5	166.14	*
1. Aldana	5	173.16	*
2. Polan	5	175.70	*

differences between the other two varieties were insignificant (173 and 176 g, respectively) and they should therefore be treated as a homogenous group. The comparison of dimensional data and 1000 seed masses leads to a conclusion that the mass of tested varieties was determined by such dimensions as their length and thickness, which were both the highest for the Aldana variety.

Mechanical damage

Negative correlations were found between mechanical damage and seed moisture content (Figs 2-4). Damage dependence on moisture content had the character of exponential function and were characterised by high correlation coefficients (Table 3). According to statistical evaluation at the significance level of $L = 0.05$ significant decreases in mechanical damage occurred at low levels of moisture content 11.5 for Aldana, and 12.5 for Polan and Progress. Assuming the value of 5 % as the acceptable limit for damage, the minimum moisture contents were determined for each variety on the basis of obtained total damage moisture content dependence. The values of moisture contents

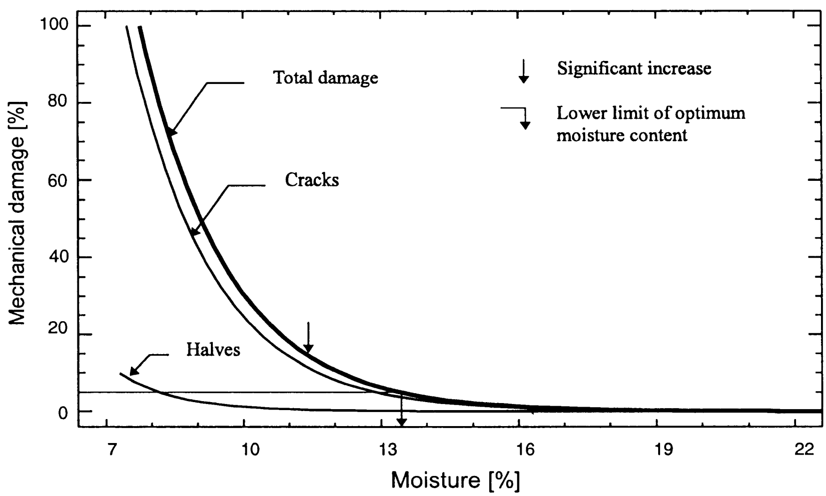

Fig. 2. Mechanical damage to soybean seeds of the Aldana variety versus their moisture content.

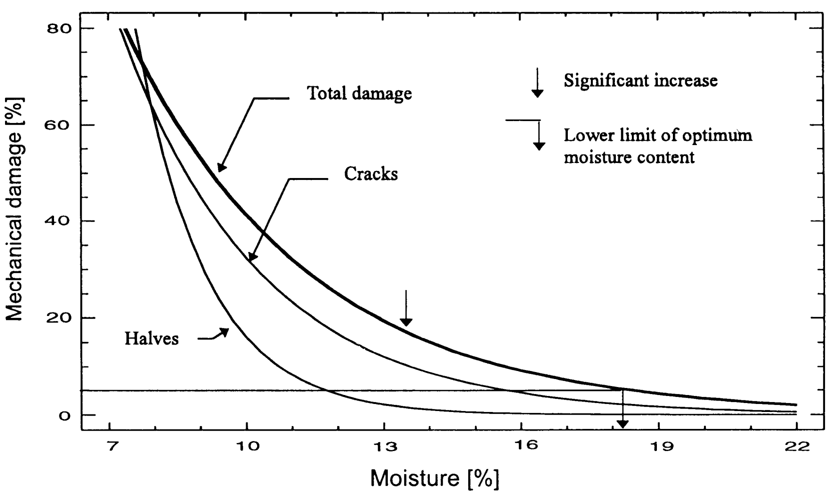

Fig. 3. Mechanical damage to soybean seeds of the Polan variety versus their moisture content.

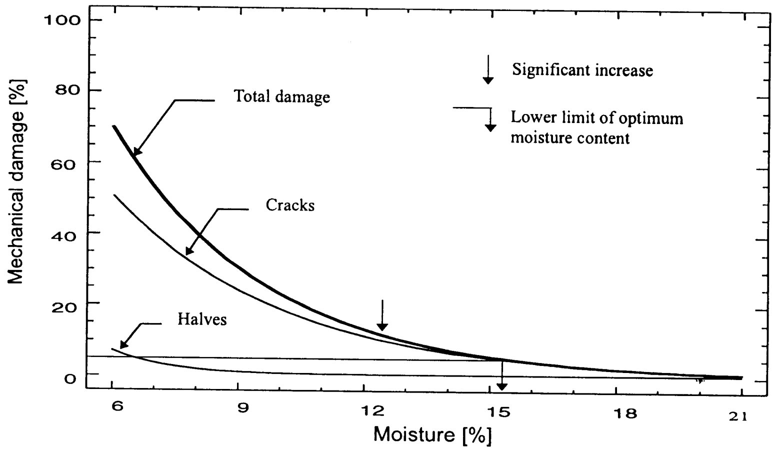

Fig. 4. Mechanical damage to soybean seeds of the Progres variety versus their moisture content.

Table 3. Values of factors in equation $y = \exp(a + bx)$ describing mechanical damage y to seeds versus seed moisture content x

Mechanical damage	Coefficients		
	a	b	R
		Aldana	
Total	8.83	-0.55	0.805
Halves	7.87	-0.79	0.841
Cracks	8.38	-0.53	0.788
		Progres	
Total	5.91	-0.28	0.944
Halves	6.56	-0.77	0.845
Cracks	5.42	-0.24	0.949
		Polan	
Total	6.23	-0.25	0.896
Halves	9.46	-0.66	0.764
Cracks	6.77	-0.32	0.601

thus determined for individual varieties differed from each other, they were: 13.1 % for Aldana, 18.5 % for Polan and 15.3 % for Progres. The majority in the damage structure were the seed cover cracks which were critical for the final result of sustained damage. The Polan variety exhibited the highest susceptibility to seed halving, especially in the moisture content range of 7.9 to 14.6 %. The comparison of the final values of damage in total resulted in no significant differences between tested varieties.

Seed sowing (seeding) value

The variation of seed energy and capability of germination versus seed moisture content are presented in Figs 5-7. Seed impacts caused a significant drop in their sowing (seeding) value, i.e., seed energy and capability of germination, which was most pronounced at low moisture content levels. At the lowest tested level of moisture content the reduction in seed energy and their capability of germination was 16 and 12 %, respectively for the Aldana variety (Fig. 5), 12 and 8 %, respectively for the Polan (Fig. 6) and 15 and 8 %, respectively for the Progres variety (Fig. 7). An increase in seed moisture content diminished the decrease in seed sowing value. The varia-tion of tested characteristics of the sowing value in relation to moisture content is described by means of function of 1st order (Table 4). From the comparison of tested varieties it should be said that, in the low moisture content range, the Aldana variety was most susceptible to reduction in seed energy and their capability of germination as a result of impacts. Seeds of that variety also exhibited the highest susceptibility to mechanical damage.

The abnormally germinating and dead seeds were not qualified as germinating. At the lowest tested level of moisture content the abnormally germinating seeds were in the majority

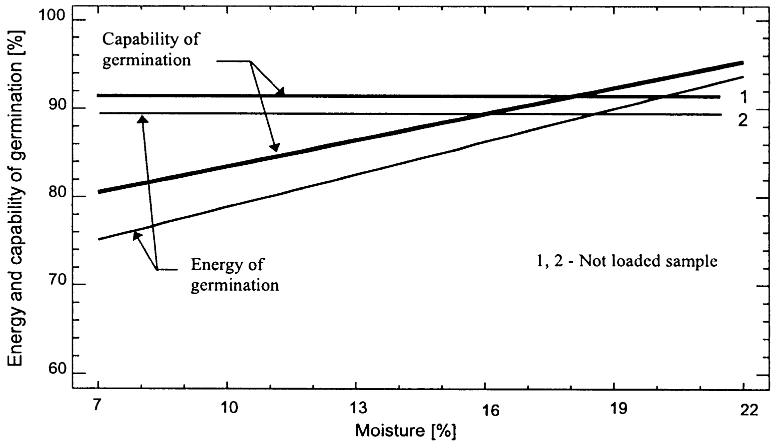

Fig. 5. Energy and capability of germination of the Aldana variety seeds versus their moisture content.

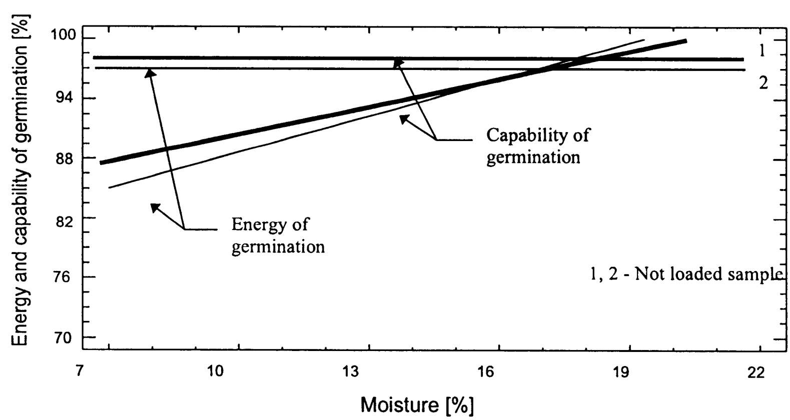

Fig. 6. Energy and capability of germination of the Polan variety seeds versus their moisture content.

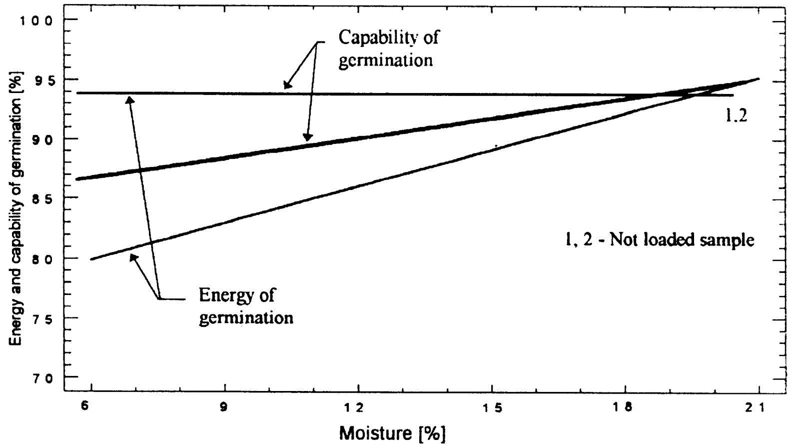

Fig. 7. Energy and capability of germination of the Progres variety seeds versus their moisture content.

Table 4. Values of factors in equation $y = a + bx$ describing seed energy and capability of germination y versus seed moisture content x

Character	Coefficients		
	a	b	R
		Aldana	
Energy of germination	66.46	1.23	0.490
Capability of germination	51.99	73.79	0.981
		Polan	
Energy of germination	76.51	1.21	0.669
Capability of germination	83.81	0.81	0.703
		Progres	
Energy of germination	73.75	1.25	0.639
Capability of germination	83.03	0.56	0.602

in all varieties, occurring in 10 to 20 % (Figs 8-10). The share of dead seeds was only 3 to 8 %. On the basis of presented results it may be said that the high share of abnormally germinating seeds had a direct effect on the final result of seed capability of germination.

DISCUSSION

As a result of the test carried out on three soybean varieties it was found that the mechanical damage of seeds which occurred caused a decrease in seed sowing (seeding) value. The sustained mechanical damage decreased and the value of seed energy and capability

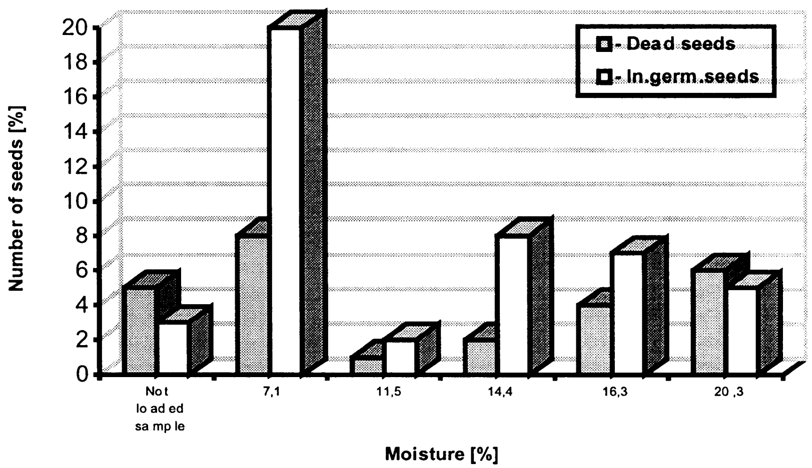

Fig. 8. Structure of the Aldana variety seeds disqualified in germination test.

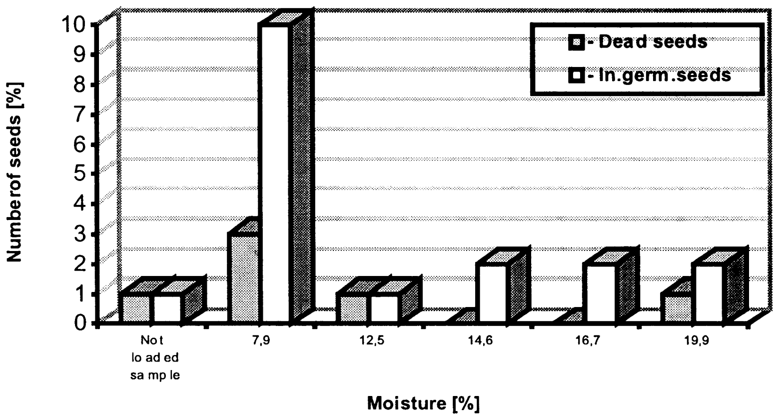

Fig. 9. Structure of the Polan variety seeds disqualified in germination test.

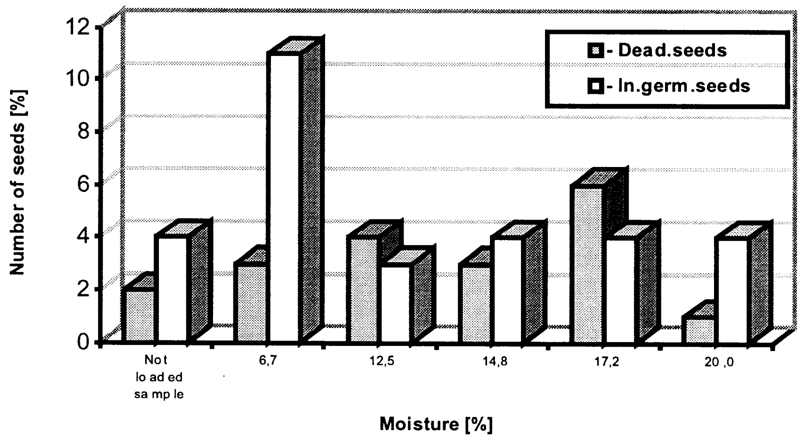

Fig. 10. Structure of the Progres variety seeds disqualified in germination test.

of germination increased with the rising seed moisture content. Such tendencies occur in many other species of seeds and were confirmed by numerous research papers [1,5]. The significant achievement of the research study presented here is in revealing the differences in optimum moisture contents (where damage did not exceed the acceptable 5 %) between individual varieties.

In this respect the tested varieties differed even though no significant differences were found in the susceptibility to damage in the whole range of tested moisture contents. The above statement is important from the practical point of view, i.e., for instance in determining the optimum conditions for operation for threshers, transporters, winnowing machines, etc.

A significant reduction in seed energy and capability of germination occurred at the low seed moisture content ranges and such seeds suffered extensive mechanical damage. In comparing the tested varieties, the Aldana variety appeared most susceptible to reduction in seed energy and capability of germination at the lowest level of moisture, while the same variety was characterised by the lowest optimum moisture content in terms of consequential damage.

The causes of the reduction in germination capability may also originate from internal damage, which was not determined in this study. Some research studies [6] indicated, though, that during loading at low moisture contents internal damage was caused which might contribute to reduction in sowing (seeding) value. The high share of abnormally germinating seeds at low moisture content levels contributed directly to the reduction of seed germination capability. The percentage of dead seeds was low. These results lead to an assumption that the suffered damage resulted in germ injury thus causing their abnormal growth. Confirmation of this assumption calls for more extensive research in this specific field of study.

CONCLUSIONS

1. Dynamic loads on seeds from impacts by steel arm revolving at circumferential speed of 21.46 ms^{-1} resulted in mechanical damage and a reduction in seed energy and capability of germination, particularly in the range of low seed moisture content (7 - 13 %).

2. In the range of tested moisture content (6.7-20.3 %) the studied varieties did not differed significantly from each other in respect of seed susceptibility to mechanical damage. On the other hand, significant differences were found between varieties in terms of optimum limits of moisture content (≥13.1 % for Aldana, ≥18.5 % for Polan and ≥15.3 for Progres variety).

3. Seed cover cracks predominated in the damage structure.

4. A significant reduction in seed energy and capability of germination was observed in low seed moisture content range (7-13%). The seed germination tests showed that in this range of seed moisture contents the abnormally germinating seeds were in the majority in the group of disqualified seeds.

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