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THE INFLUENCE OF COMBINE HARVEST ON THE VIGOUR AND SOWING VALUE OF NARROW-LEAVED LUPIN SEEDS

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Abstract. The research was conducted on the basis of the field experiment which was carried out in 2011 and 2012 at the Experimental Station Złotniki of the Poznań University of Life Sciences. The aim of this study was to determine the effect of combine harvest on the seed quality of narrow-leaved lupin. Two factors were studied: the cultivar of narrow-leaved lupin (the indeterminate Zeus cv. and the determinate Regent cv.) and harvest method: hand-picked plants with manual shelling of seeds (control) and combine harvest. The higher germination and vigour were found in the case of seeds the determinate Regent cultivar. In comparison with manual harvest, the combine harvest reduced the seed germination after 5 and 10 days and increased the percent of abnormally germinated and ungerminated seeds both cultivars. The results of the electrical conductivity test and vigour index showed the decrease of vigour both cultivars due to combine harvest.

Key words: combine harvest, narrow-leaved lupin, sowing value, vigour

INTRODUCTION

Narrow-leaved lupin is one of the three lupin crop species. Lupin cultivation gained recently much attention, due to the fact that lupin is a valuable source of protein [Kamel et al. 2012, Stanek et al. 2012]. Lupin can be grown in more temperate or cool climates and it can be considered as the strongest potential competitor of soybean [Dueñas et al. 2009]. In various parts of the world, lupin seeds are used as a source of protein for animal and human nutrition [De Cortez Sánchez et al. 2005]. Farmers are interested in buying and cultivating vigorous seeds in order to improve crop performance in the field [Ghassemi-Golezani and Hosseinzadeh-Mahootchy 2009]. The large size of lupin seeds make them vulnerable to mechanical damage during harvesting, which can influence their quality.

According to Ellis [1992] the seed quality is a broad term and it includes several factors: varietal, seed health and physical purity, vigour, germination, and size (or weight). In theory seed germination, vigour and size (three aspects of seed quality) may have both: direct and indirect influence on crop yield [Ellis 1992]. The quality control plays an important role to assure the production of high quality seed in all processes ranging from pre-harvest on the farm, through processing and to the final stage of seed storage [Henning et al. 2006]. One of the factors, that can reduce the seed quality are mechanical damages. The large size of legume seeds makes them vulnerable to mechanical damages by the header at harvest and during subsequent handling. These damages are not always visually apparent [Matthews and Holding 2005]. Even little damage done to seeds during processing may rapidly affect seed viability and cause seed vigour to decrease and increase the number of abnormal seedlings [Schenidt 2000].

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The aim of this study was to determine the effect of combine harvest on the seed quality of narrow-leaved lupin's cultivars.

MATERIALS AND METHODS

The research was conducted on the basis of the experiment which was carried out in 2011 and 2012 at the Experimental Station Złotniki (52°29′ N, 16°49′ E, Poland) on grey-brown podsolic soil. The experiment was laid out in randomized complete block design with split plot arrangements with 4 replications. Two factors were studied: the cultivar of narrow-leaved lupin (the indeterminate Zeus cv. and the determinate Regent cv.) and harvest method (hand-picked plants with manual shelling of seeds as a control and combine harvest). The plots of 20 m^2 were prepared by ploughing. A fertilisation (P_2O_5 – 80 kg·ha-1 and K_2O – 120 kg·ha^{-1}) was applied to the seedbed after previous crop harvest. Inoculated seeds were drilled in early April: the Zeus cultivar at a rate of 150 kg ha^{-1} and the Regent cultivar at a rate of 160 kg·ha^{-1}. The weeds were controlled by post-emergence treatment with 2.0 l·ha^{-1} of linuron (Agan Chemical Manufactures Ltd.). Manual and combine harvest were done during the phase of full ripeness of the seeds with 14–15% moisture. After the harvest all samples were stored in brown paper bags under cool conditions. The analyses of sowing value and vigour were made in a laboratory at the Department of Agronomy, Poznań University of Life Sciences. The standard germination test and the electrical conductivity test were made according to ISTA Rules [2006]. The first count was after 5 days (germination after 5 days) and the final count after 10 days (germination after 10 days). There was evaluated percentage of normal seedlings. After 10 days were counted also the abnormally germinated seeds (abnormal seedlings) and ungerminated seeds. The ungerminated seeds contained: dead seeds (soft, mouldy) and fresh seeds. The seedling growth test and the seedling growth rate test were made according to Dąbrowska et al. [2000]. The vigour index was calculated as the product of the results of the seedling growth test in cm and the average germination in %. All analyses pertaining to the viability and vigour of the seeds were based on the seed samples collected from each experimental plot.

All the data were evaluated statistically using the analysis of variance for two-factorial experiments. The means of treatment were compared by means of Tukey's least significant difference test (LSD) at $p<0.05$. The relationship between the seed characteristics was determined with the Pearson correlation coefficient.

RESULTS AND DISCUSSION

The higher average germination after 5 and 10 days were found in the case of seeds the determinate Regent cultivar (89% and 93%, respectively) (Table 1). The percentage of abnormally germinated and ungerminated seeds of Regent cultivar was by 8% lower than that of the indeterminate Zeus cultivar. The sowing value differed depending on the cultivar and in combination with specific harvest method. Combine harvest significantly decreased the seed germination after 5 and 10 days and increased the percentage of abnormally germinated and ungerminated seeds both cultivars, as compared with the manual shelling of seeds. The loss of quality Zeus cultivar was higher (germination after 5 and 10 days about 18% and 20% respectively) than in Regent cultivar (5%). On average, the combine harvest decreased germination and increased the percentage of abnormally germinated and ungerminated seeds by 12%. Verasilpa et al. [2001] claim that the larger seeds have a thinner seed coat and are more mechanically damaged. When damage of seed is close to the embryonic axis, the probability of producing abnormal seedlings rises, but

Table 1. Sowing value of narrow-leaved lupin seeds depending on experimental factors (%)

Cultivar (A)	Harvest method (B)		
	manual	combine	mean
Germination after 5 days			
Zeus	92	72	82
Regent	92	87	89
Mean	92	80	–
$LSD_{0.05}$: A – 4.6; B – 3.3; A × B – 4.7			
Germination after 10 days			
Zeus	94	76	85
Regent	95	90	93
Mean	95	83	–
$LSD_{0.05}$: A – 3.4; B – 2.8; A × B – 3.9			
Abnormally germinated and ungerminated seeds			
Zeus	6	24	15
Regent	5	10	7
Mean	5	17	–
$LSD_{0.05}$: A – 3.4; B – 2.8; A × B – 3.9			

if damage occurs far from the embryonic axis, the possibility of producing normal seedlings increases [Maryam and Oskouie 2011]. In the experiment conducted by Maryam and Oskouie [2011] there were significant differences in seed germination percentage and in mechanical damage between the soybean cultivars. These results show that the character of mechanical damage is one of the traits related to the cultivar, especially it is related to seed coat characteristics, i.e. the more integrated the seed coat is and the higher the lignin content is, the more resistant it is to mechanical damage. The lignin content in the seed coat is correlated with the index of seed resistance to mechanical damage [Capeleti et al. 2005]. If the seed coat is thinner and more fragile, the susceptibility to mechanical damage increases [Maryam and Oskouie 2011].

The germination test is widely accepted and frequently used as an indicator of the quality of a seed lot. However, under field/greenhouse conditions the germination test overestimates the performance of seeds because it is performed under optimal conditions for each species. Furthermore, it is inadequate for discriminating between seed lots in terms of the speed and uniformity of seed germination [Copeland and McDonald 2001]. The vigour tests are used to indicate the relative emergence performance of seed lots more reliably than with a standard germination test [Matthews et al. 2009].

In conducted experiment the determinate Regent cultivar showed significantly higher vigour than indeterminate Zeus cultivar (Table 2). Its leakage of exudates was lower (27.0 $\mu S \cdot cm^{-1} \cdot g^{-1}$), the seedlings were longer (9.6 cm) and heavier (34.7 mg) and its vigour index was higher (897). The results of the electrical conductivity test and vigour index showed the decrease of vigour both cultivars due to combine harvest. On average, the all tests confirmed that the combine

Table 2. Vigour of narrow-leaved lupin seeds depending on experimental factors

Cultivar (A)	Harvest method (B)		
	manual	combine	mean
Electrical conductivity test ($\mu S \cdot cm^{-1} \cdot g^{-1}$)			
Zeus	41.3	46.3	43.8
Regent	23.4	30.6	27.0
Mean	32.4	38.4	–
$LSD_{0.05}$: A – 2.7; B – 2.8; A × B – 3.8			
Seedling growth test (cm)			
Zeus	8.7	6.0	7.3
Regent	10.1	9.2	9.6
Mean	9.4	7.6	–
$LSD_{0.05}$: A – 0.9; B – 0.8; A × B – 1.3			
Seedling growth rate test (mg)			
Zeus	30.7	31.8	31.3
Regent	36.8	32.6	34.7
Mean	33.8	32.2	–
$LSD_{0.05}$: A – 2.3; B – 1.4; A × B – 2.7			
Vigour index			
Zeus	821	464	643
Regent	968	825	897
Mean	895	644	–
$LSD_{0.05}$: A – 89; B – 92; A × B – 131			

harvest decrease the vigour of seeds. The large size of legume seeds makes them vulnerable to mechanical damages during harvest [Matthews and Holding 2005]. Matthews and Powell [2006] claim that the seed lots with little testa damage imbibe slowly, show little imbibition damage and have high emergence. This emphasizes the importance of the integrity of the testa in determining the vigour of some species of legume grain and hence the need to minimize damage to the testa during harvest and processing. In the experiment by Maryam and Oskouie [2011] the cultivar of soybean with the best germination percentage had the highest percentage of mechanical damage and the highest result of the electrical conductivity test. These authors claim that in the electrical conductivity test which evaluates seed vigour and viability, a damaged seed coat allows seed matters to exit and a damaged seed has higher exudation and a higher rate of electrical conductivity. But the high levels of leakage are characteristic of low vigour lots with acceptably high levels of laboratory germination but with low field emergence, particularly in cold, wet soils [Matthews and Powell 2006]. A characteristic feature of legume seeds is a great diversity between the planned and the really obtained in field conditions seed germination ability, which has an impact on plant emergence in the field [Faligowska and Szukała 2008]. In

order to overcome these inconveniences, the seed vigour concept was proposed [Contreras and Barros 2005]. In carried out experiment the Pearson's linear correlation between the respective vigour tests and germination after 10 days of combine harvest showed that these parameters were correlated to a varied extent (Table 3). The strongest relations, where the correlation coefficient was greater than 0.75, were found between: the vigour index and the seedling growth test, the vigour index and the electrical conductivity test. The ISTA Rules for Seed Testing [ISTA 2006] included the electrical conductivity test for garden peas (*Pisum sativum*). In conducted experiment relations between the vigour index and the electrical conductivity test both cultivars were strong. The electrical conductivity test can be useful also for lupin. Legumes with large, normally living cotyledons are good candidates for the electrical conductivity vigour test to indicate field emergence, because they still germinate in the laboratory even with considerable areas of dead tissue on their cotyledons provided that critical areas of the embryo remain living [ISTA Rules 2003].

Table 3. The correlation coefficients between laboratory measures in combine harvest

Cultivar	Parameters compared	Germination after 10 days	Electrical conductivity test	Seedling growth test	Seedling growth rate test	Vigour index
Zeus	Germination after 10 days	1.000				
	Electrical conductivity test	-0.960***	1.000			
	Seedling growth test	0.592*	-0.567*	1.000		
	Seedling growth rate test	-0.516*	0.562*	-0.499	1.000	
	Vigour index	0.850**	-0.818**	0.924**	-0.510*	1.000
Regent	Germination after 10 days	1.000				
	Electrical conductivity test	-0.145	1.000			
	Seedling growth test	-0.421	0.868**	1.000		
	Seedling growth rate test	-0.025	0.670*	0.642*	1.000	
	Vigour index	-0.204	0.917**	0.973***	0.694*	1.000

* – $p<0.05$, ** – $p<0.01$, *** – $p<0.001$

CONCLUSIONS

1. In the case of seeds the determinate Regent cultivar was found greater germination and vigour compared to indeterminated Zeus cultivar.
2. The combine harvest significantly decreased the seed germination and increased the percentage of abnormally germinated and ungerminated seeds both cultivars.

3. The results of the electrical conductivity test and vigour index showed the decrease of vigour both cultivars due to mechanical harvest.
4. The correlation coefficients showed the strongest relations between: the vigour index and the seedling growth test, the vigour index and the electrical conductivity test.

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WPŁYW ZBIORU KOMBAJNOWEGO NA WIGOR I WARTOŚĆ SIEWNĄ NASION ŁUBINU WĄSKOLISTNEGO

Synopsis. Badania były prowadzone na podstawie doświadczenia polowego przeprowadzonego w latach 2011–2012 w Zakładzie Doświadczalno-Dydaktycznym w Złotnikach, należącym do Uniwersytetu Przyrodniczego w Poznaniu. Celem doświadczenia było określenie wpływu zbioru kombajnowego na jakość siewną nasion łubinu wąskolistnego. Czynnikami doświadczenia były: odmiana (łubin wąskolistny o niezdeterminowanym typie wzrostu – Zeus i o zdeterminowanym typie wzrostu – Regent) oraz metoda zbioru: ręczny (kontrola) oraz kombajnowy. Lepszy wigor i kiełkowanie nasion po 5 i 10 dniach stwierdzono w przypadku nasion samokończącej odmiana Regent. W porównaniu ze zbiorem ręcznym, zbiór kombajnowy powodował obniżenie kiełkowania oraz wzrost udziału nasion anormalnie kiełkujących i niekiełkujących obu odmian. Test elektroprzewodnictwa oraz indeks wigoru wykazały obniżenie wigoru nasion pod wpływem zbioru kombajnowego.

Słowa kluczowe: łubin wąskolistny, wartość siewna, wigor, zbiór kombajnowy

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