Effect of Pinolen on winter rape seed losses in relation to maturity

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Abstract. Research objective: To determine the effect of Pinolen (Aventrol) and carbamate solutions on winter rape seed yields under Lithuanian conditions. Research place and time: Bariunai agricultural holding, Joniskis region., Lithuania. Trials were carried out in 2007–2008. Trial field soil: *JDg8-K(LVg-p-w-cc) Calc(ar)i-Epihypogleyic Luvisols.* Research methods: Field trials, and biometric analysis of rape plants. Research data evaluation: Two-year research data confirmed the hypothesis of the authors that, in the winter rape crop, leaf-spray fertilization with Pinolen (0.5–1.0 l ha^{-1}) solutions three weeks before crop maturity results in the formation of an elastic capsule around the siliques and prevents them from splitting open with consequent loss of seed. Pinolen efficacy is greater in disease or pest damaged crops, and crops harvested late. From the economic and labour planning points of view, leaf-spray fertilization of winter rape with Pinolen should be combined with additional leaf-spray fertilization with carbamate solutions (20 kg ha^{-1}). Leaf-spray fertilization of winter rape with Pinolen (1.0 l ha^{-1}) + carbamate (20 kg ha^{-1}) solutions resulted in seed yield increases: in the 2007 trial by 0.64 and in the 2008 trial by 0.320 t ha^{-1}. Of the total seed augmentation, the Pinolen effect accounted for 33.3%. The protective efficacy of the capsule starts to decrease five weeks after leaf spray fertilization of the crop with these solutions.

Key words: winter rape *(Brassica napus var. oleifera)*, Pinolen, Carbamate, seed loss, seed productivity

INTRODUCTION

Sowing time, seed norms, different levels of fertilization, peculiarities of plant protection systems as well as other agrotechnical factors affect winter rape seed yield (Velička, 2002). Much of the yield is lost due to ineptitude to fit agrotechnics to biological rape features at different rape growth stages (Liakas et al., 2005; Liakas et al., 2006). One of the causes for unstable winter rape yields is considered to be seed loss from the siliques just before and during harvest. Mature rape siliques split open prematurely due to unfavourable environmental conditions (strong wind, rain, birds) and the seeds are lost. Commonly, if the rape is harvested at the optimum time, seed losses (before, and during harvest) are only 4–5%, however, if harvesting is late, or carried out by a not prepared or not adjusted combine harvester, seed losses can be 15–30% (Špokas & Domeika, 1993). Scientists in the UK found that, at the beginning of the absolute rape maturity, over the seven day period, only about one percent of the seeds are lost from the siliques, however if the harvesting is even later natural seed losses are much higher and can reach 10%. Besides, later harvesting results not only in higher natural seed losses but also in lower seed quality (Price et al., 1996). This is in full agreement with the findings of Czeckia scientists. They indicate that, if optimum harvesting times are not observed, harvest losses range from three to five percent and sometimes can even reach ten percent (Vašak & Fabry, 1981). Rape scientists from Belarus indicate that farms in their country harvest rape plants later and wait until the seed moisture does not exceed 10–12% in order to reduce expenditure on seed desiccation (Tsiganov & Klochkova, 2006). They calculated that harvesting rape even later results in much higher natural seed losses the cost of which exceeds the funds saved on seed desiccation several times. Seed losses tend to increase in rainy years. In agriculture, various measures are applied to prevent shedding of seed. The most wide-spread is diphase harvesting when rape is swathed during the oil maturity stage and left to dry for five to ten days, and only then threshed (Mackowiak & Goworko, 1972). In our opinion of much higher importance is timely and targeted pesticide application, which substantially reduces pest and disease caused damage. Siliques of the healthy plants are much more resistant to self-opening. Damaged rape plants not only grow and develop poorly but also mature about 7–12 days earlier. Siliques that mature earlier and are damaged open earlier with seed loss. Splitting open of the siliques is substantially stimulated by damage caused by the Brassica pod midge (*Dasineura brassicae)* and the Cabbage seed weevil (*Ceutorhynchus assimilis)*. Therefore, correct and timely plant protection not only improves plant growth, but also reduces possible seed loss. In the USA and Canada, scientists suggest that loss of rape seeds before and during the harvesting can be substantially reduced by spraying the rape crop with the gummy preparation Aventrol two – three weeks before seed maturity. It also can be used to strengthen the effect of fungicides and herbicides (Prokop et al., 2003, 2006). Aventrol is a preparation of organic origin, the basis of which is pinolen (960 g l^{-1}) dissolved in a solvent.

Pinolen is produced from the natural resin of deciduous plants and practically contains no any other ecologically impure chemical compounds, which could be harmful for the environment and poisonous when using the products produced for food, feed, in confectionary or cosmetics.

Resins of deciduous trees, like that of other trees, have gummy properties which provide necessary protection from the injuries caused due to contact with the environment. Besides they contain phytoncides, i.e they considerably reduce the possibility for damage to spread (Poe & Green, 1975). Aventrol is used to cover the siliques of maturing rape with an elastic capsule, which can substantially reduce the splitting open of over-mature or damaged siliques and loss of their seed. A very important characteristic of the Aventrol is that the capsule it forms does not interfere either with respiration or with transpiration processes; however it considerably reduces the access of mature siliques to moisture from the atmosphere (Rauckis, 2008).

The aim of our research was to investigate the time of Aventrol use, spraying norms and the possibility of regulating the applications of carbamate solutions and Aventrol.

MATERIALS AND METHODS

Research time and place. Bariunai agricultural holding, Joniskis region. The trials were carried out in 2007–2008. Research plot soil - *Endocalcari – Endohypogleyic Cambisol* (*Cmg-n-w-can*), heavy clay loam on dusty clay with deeper (at the depth of 1m) sandy clay.

Research scheme:

Variant 1. No applications (control);

Variant 2. Aventrol 0.5 l ha^{-1} + Carbamate 20 kg ha^{-1};

Variant 3. Aventrol 0.75 l ha^{-1} + Carbamate 20 kg ha^{-1};

Variant 4. Aventrol 1.0 l ha^{-1} + Carbamate 20 kg ha^{-1}.

The applications were carried out on 29 – 30 June, approximately three weeks before optimum harvesting time. The effects of the considered factors on winter rape seed yield were analysed for different rape harvesting times:

1. Rape was threshed 42 days after flowering;
2. Rape was threshed 50 days after flowering;
3. Rape was threshed 57 days after flowering.

Precrop - winter wheat. Winter rape variety *'Elvis'.* On the trial plot, winter rape was grown using intensive growing technology approved by the Plant Growing and Animal Husbandry Department at the Lithuanian University of Agriculture (LŽŪU). The expected seed yield was not lower than 4 t ha^{-1}.

The area of the research plots – 120 m^{-2}. Replications – four. Variants in replications were set at random.

The research was carried out following plant growing methods of the Lithuanian University of Agriculture.

Before rape harvesting and a day after it rape seed loss was counted on 400 cm^2 plots.

Research results were statistically evaluated employing the method of the dispersive analysis (Tarakanovas & Raudonius, 2003).

RESULTS AND DISCUSSION

In the 2007 trials, rape seed losses were counted 42 days after flowering, before harvesting and during harvesting. The reasons of the losses were not determined. In the control (no applications), 123 kg ha^{-1} seeds were lost, whereas during harvest an additional 49 kg ha^{-1} were lost, a very high number (table 1). At that time disease damaged plants could be clearly seen. The observations indicated that, during the milky stage, 50–70% of the rape plants were damaged by sooty rot (*Botrytis cinerea Pers.),* and sclerotic rot (*Sclerotinia sclerotiorum).* At that time, the plants were of a yellowy-green colour, and ten days later their vegetation was over. The siliques took on a brown colour and started opening. Therefore, most of the seeds lost were from damaged plants. The application of 0.5 l $ha^{-1}$of Aventrol and 20 kg ha^{-1} of carbamate resulted in 60.1% decrease in seed loss, whereas during harvesting this decrease was 26.5%. The 0.75 l ha^{-1} norm recommended by Aventrol thus reduced rape seed loss sevenfold. An even greater effect (22 times) was obtained in the variant where 1.0 l ha^{-1} of the Aventrol and 20 kg ha^{-1} of the carbamate solutions were applied.

Table 1. Effect of the Aventrol and carbamate solution applications on winter rape seed loss before rape and after harvesting, kg ha^{-1}.

Bariunai (2007)

Variants	Before harvesting	During harvesting	Total
42 days after flowering			
1. No applications (control)	123	49.0	172
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	49.0	36.0	85.0
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	17.0	27.0	44.0
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	5.83	24.8	30.6
LSD_{05}	*3.604*	*2.826*	*4.686*
50 days after flowering			
1. No applications (control)	172	179	351
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	70.0	83.5	154
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	41.0	61.0	102
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	16.0	42.0	58
LSD_{05}	*6.501*	*8.188*	*12.87*
57 days after flowering			
1. No applications (control)	421	383	804
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	316	194	510
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	168	106	274
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	37.0	51.0	88.0
LSD_{05}	*22.27*	*18.53*	*31.87*

When seed loss was counted on the 50th day after flowering, even 40% of the seeds lost before harvesting, and 3.65 times more during the harvest were recorded. The total seeds lost in the control was 351 kg ha^{-1}, whereas in the variant where the mixture solution of 1.0 l ha^{-1} Aventrol and 20 kg ha^{-1} of carbamate were applied only 58 kg ha^{-1} or by 6.05 times less seeds was found than in the control. Seed counting in overmature crops (57 days after flowering) confirmed our hypothesis, that later rape harvesting results in fewfold higher yield losses. Before harvesting 421 kg ha^{-1} seeds were lost, during harvesting 383 kg ha^{-1}. The total amounted to 804 kg ha^{-1} of seeds. In the variants where the Aventrol 0.5 l ha^{-1} and 20 kg ha^{-1} carbamate mixture solutions were not applied the protective Aventrol effect was over and seed loss was 316 kg ha^{-1}. During harvesting, an additional 194 kg ha^{-1} seeds were lost. Meanwhile, in the fourth variant (Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}) only 37 kg ha^{-1} before the harvesting, and – 51 kg ha^{-1} during the harvesting of the rape seeds were lost. The twofold lower Aventrol norm resulted in 8.5 times lower seed loss before harvesting and 3.8 lower seed loss during harvesting. The effect was substantial.

Vegetation conditions in 2008 were substantially different from those in 2007. Although winter rape started flowering 10–12 days earlier in 2008 than in 2007, the duration of flowering itself was 15–17 days longer. The longer flowering period and the timely application of pesticides created optimum conditions for strong siliques to form. In 2008, winter rape growth and development was even and long. Until the milky stage, the rape crop was little damaged by diseases. The number of pest damaged plants was also lower than in 2007. The counting of the lost seeds started on the 42nd day after rape flowering (table 2). The data for that date indicated that the quantity of seed lost was low (10.0 kg ha^{-1}).

Table 2. Effect of the Aventrol and carbamate sollution applications on winter rape seed loss kg ha^{-1}.

Bariunai (2008)

Variants	Before harvesting	During harvesting	Total
42 days after flowering			
1. No applications (control)	10.0	31.0	41.0
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	3.50	14.0	17.5
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	4.00	12.0	16.0
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	3.50	12.0	15.5
LSD_{05}	*0.526*	*1.787*	*1.858*
49 days after flowering			
1. No applications (control)	25.0	66.0	91.0
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	8.00	31.0	39.0
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	7.50	24.0	31.5
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	6.00	22.5	28.5
LSD_{05}	*1.052*	*3.707*	*3.827*
56 days after flowering			
1. No applications (control)	40.5	105	145
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	17.0	62.0	79.2
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	13.5	40.3	53.8
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	9.50	33.5	43.0
LSD_{05}	*1.994*	*5.480*	*4.509*

During winter rape harvesting an additional 31 kg ha^{-1} of seed was lost. Total loss for that date was 41 kg ha^{-1}. Aventrol and carbamate different norm applications reduced seed loss both before and after harvesting.

In the variant where Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1} solution was applied the total seed loss was by 15.5 or 25.5 kg ha^{-1} seeds lower than in the control.

Results of the second count (after 49) showed that, a week before rape harvesting, seed loss was 25 kg ha^{-1}, whereas during harvest it was 66 kg ha^{-1}. Application of the considered solutions was shown to substantially reduce seed losses both before and during harvest.

Counting of the seeds 56 days after flowering, indicated that, under the conditions of the year 2008, seed loss in the over-mature crop was not as great as it was in the year 2007. In the control, the total seed loss was 145 kg ha^{-1}: 40.5 before harvesting and 105 kg ha^{-1} during harvesting.

In the 2008 trial, seed loss was by 4.2–5.5 lower than in the trial of 2007. Such a high difference between years was predetermined by the fact that in 2008 the crop was much healthier and the active vegetation was longer. R. Velička, L. Špokas et. al obtained similar results. They indicate that, due to unfavourable meteorological conditions, the 7 day delay in harvesting resulted in 093 t ha^{-1} or 32 % lower biological seed yield. Meanwhile, under favourable meteorological conditions even harvesting 11 days later resulted in minimum seed losses (Velička et al., 2003). Analysis of the 2007 winter rape threshing data obtained 42 days after flowering revealed that Aventrol and carbamate mixture solutions resulted in rape seed yield increase by 0.28–0.37 t ha^{-1} (Table 3). Seven-day later threshing revealed seed yield differences of 0.42–0.64 t ha^{-1}. Even greater differences were obtained threshing rape on the 56th day after flowering.

Table 3. Effect of the Aventrol and carbamate solutions winter rape seed yields.

Bariunai (2007)

Variants	Seed yield t ha^{-1}	Yield addition, as compared to control
Threshed 42 days after flowering		
1. No applications (control)	2.61	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	2.89	0.28
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	2.94	0.33
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	2.98	0.37
LSD_{05}	*0.151*	–
Threshed 50 days after flowering		
1. No applications (control)	3.35	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	3.77	0.42
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	3.87	0.52
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	3.99	0.64
LSD_{05}	*0.202*	–
Threshed 57 days after		
1. No applications (control)	2.50	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	3.06	0.56
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	3.31	0.81
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	3.54	1.04
LSD_{05}	*0.212*	–

Table 4. Effet of the Aventrol and carbamate sollutions on seed yield.

Bariunai (2008)

Variants	Seed yield t ha^{-1}	Yield addition, as compared to control
Threshed 42 days after flowering		
1. No applications (control)	4.140	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	4.386	0.246
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	4.385	0.245
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	4.393	0.253
LSD_{05}	*0.364*	–
Threshed 49 days after flowering		
1. No applications (control)	4.321	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	4.604	0.283
3. Aventrol 0.75 l ha^{-1} + carbamate 20 kg ha^{-1}	4.615	0.294
4. Aventrol 1.0 l ha^{-1} + carbamate 20 kg ha^{-1}	4.624	0.303
LSD_{05}	*0.310*	–
Threshed 56 days after flowering		
1. No applications (control)	4.450	–
2. Aventrol 0.5 l ha^{-1} + carbamate 20 kg ha^{-1}	4.765	0.315
3. Aventrol 075 l ha^{-1} + carbamate 20 kg ha^{-1}	4.797	0.347
4. Aventrol 10 l ha^{-1} + carbamate 20 kg ha^{-1}	4.802	0.352
LSD_{05}	*0.194*	–

Then seed yield in the control was 1.04 t ha^{-1} lower than in the variant where a mixed solution of Aventrol 1.0 l ha^{-1} and carbamate 20 kg ha^{-1} was applied.

In the trial of 2008, winter rape productivity was by 1.29–1.78 times higher than in the trial of 2007. Analysis of the trial data revealed that later rape harvesting resulted in substantially higher productivity. Application of the Aventrol and carbamate mixture solutions for the considered harvesting dates resulted in substantial increase in winter rape seed productivity. Productivity increase was obtained due to lower seed loss both before harvesting and during it, and due to the positive effect of carbamate on rape seed yield. A trend revealing that later rape harvesting resulted in higher rape yield additions due to application of Aventrol and carbamate solutions was found. As in the 2007 trial, higher Aventrol application norms resulted in greater seed yield gains.

To determine the effect of Aventrol and carbamate for each separate yield addition, calculations were performed. From the overall yield increase we deducted the seed loss values obtained for the different variants. In 2007, the carbamate effect on yield increase exceeded Aventrol efficiency threshing rape on the 42nd day after flowering. Then the change in yield increase due to Aventrol application was 0.087–0.141 t ha^{-1}. The effect of the carbamate - 0.193–0.229 t ha^{-1}. In the trial of 2007, due to delays in rape threshing, the effect of Aventrol on yield increase was greater and rape threshed on the 57th day after flowering where Aventrol 1.0 l ha^{-1} and 20 kg ha^{-1} mixture solution was applied the obtained seed yield addition was 1.04 t ha^{-1}, of that number due to Aventrol effect 0.715, whereas due to carbamate effect – 0.325 t ha^{-1}. In the trial of 2008, a two week delay in rape threshing resulted in an increased seed yield due to application of the considered solution of only 0.352 t ha^{-1}, of that number due to Aventrol – 0.102, whereas due to carbamate – 0.25 t ha^{-1}. In the trial of 2007, seed yield increases obtained due to Aventrol application were 5.42–7.01 times greater than in 2008. Thus, we may conclude that economic efficiency of the Aventrol application is much higher in either disease or pest damaged crops, as well as their later threshing.

In 2008, according to rape reaping terms (42, 49 and 57th day after the end of flowering) the application of Aventrol 1 l ha^{-1} + carbamate 25 kg ha^{-1} solutions resulted in rape seed yield increases of 0.25, 0.30 and 0.35 t ha^{-1}, respectively. Although the seed amount was considerably lower than in 2007, nonetheless it was substantial enough to consider the applications profitable.

The rise in Aventrol norms did not result in the biological decrease in rape seed yield but even showed a trend to increase it. The effect of the carbamate on rape applying different Aventrol norms prolonged active plant vegetation which in its turn resulted in decrease in seed loss and increase in seed yields.

CONCLUSIONS

In Lithuania, different reasons (disease, pests, birds, delays in rape seed harvest result, poor combine harvesters, weather hazards) result in seed losses. Before and during the harvest generally seed loss from disease and pest damaged plants are, on average, 350–800 kg ha^{-1} seed, whereas in disease damaged crops they are 90–145 kg ha^{-1}.

Two years of research data revealed that application of Aventrol (1.0 l ha^{-1}) + carbamate 20 kg ha^{-1} mixture solutions resulted in seed loss 8–10 times lower in a year with unfavourable weather conditions and 3–5 times lower in a year with favourable weather conditions.

The positive effect of Aventrol in reducing seed loss before and during harvest is greater when the harvest is delayed.

In order to make the application of the Aventrol economically effective, the Aventrol 1.0 l ha^{-1} and carbamate 20 kg ha^{-1} mixture solutions solutions should be applied. Application of such a norm increased rape seed yield on average by 250–400 kg ha^{-1}. The value of the increased yield exceeded the cost of application.

REFERENCES

Domeika, R., Špokas, L. & Butkus, V. 1999. Research of rapeseed harvesting Losies. *Proceedings of the Latvia university of agriculture.* Jelgava, **1**(295), pp. 28–35.

Krey, H. 2003. Auftreten von Krankheiten im raps. *Raps.* **21**(2), pp. 66–69 (in German).

Liakas, V., Malinauskas, D. & Šiuliauskas, A. 2005. Impact of the additional winter rape fertilization through leaves on seed yields and elements of yield structure. Agronomijas Vestis. Latvia University of Agriculture Institute of Soil Management. Jelgava, **8**, 112–117.

Liakas, V., Malinauskas, D. & Šiuliauskas, A. 2006. Žieminių rapsų pasėlio tankumo įtaka jų augalų produktyvumui ir derliui. *Žemės ūkio mokslai*. **2,** 18–23 (in Lithuanian, English abstr.).

Mackowiak, W. & Goworko, L. 1972. Dwufazovy zbiornajbarziej skazana metoda zbioru rzepaku ozimiego. *Nowe Roln.* **1**, 15 pp. (in Czech).

Poe, S.L., Green, J.L., Vidyarthi, A.D. & Poppell, J. 1975. Prolonged chemical residues on foliage by treatment with pinolene. *Florida State Horticultural Society*, pp. 556– 559.

Price, J.S., Holson, R.N., Neole, M.A. & Bruce, D.M. 1996. Seed Losses in Commercial harvesting of Oilseed Rape. *Journal of Agricultural Engineering Reseach* **65**(3), 183–191.

Prokop, M. & Veverka, K. 2003. Influence of droplet spectra on the efficiency of contact and systemic herbicides. *Plant, Soil and Environment* **49**, 75–80.

Prokop, M. & Veverka, K. 2006. Influence of droplet spectra on the efficiency of contact fungicides and mixtures of contact and systemic fungicides. *Plant Protect. Sci.* **42**, 26–33.

Rauckis V. 2008. Aventrol – preparatas, neleidžiantis rapsų sėkloms išbirti iš ankštarų: < *http://www.kustodija.lt/pdf/Straipsnis%5B1%5D.pdf*> (in Lithuanian).

Šidlauskas, G. 2002. Žieminių ir vasarinių rapsų (Brassica napus L.) vystymosi ir derliaus formavimosi ryšiai su aplinkos veiksniais. *Habilitacinis darbas.* Akademija, 150 pp. (in Lithuanian, English abstr.).

Špokas, L. & Domeika, R. 2001. Rapsų pjūties sėklų nuostolių mažinimas. *Šiuolaikinės augalininkystės technologijos.* Akademija, pp. 32–40 (in Lithuanian).

Tarakanovas, P. & Raudonius, S. 2003. Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas ANOVA, STAT, SPLIT-PLOT iš paketo SEEKCIJA ir IRRISTAT. *Akademija*, 56 pp. (in Lithuanian).

Vašak, J. & Fabry, A. 1981. Hlavni redukujien faktory pri tvorbe vynosu ozimia repky. *Uroda* **29**(4), 284 pp. (in Czech).

Velička, R. 2002. *Rapsai*. Kaunas: Lututė. 320 pp. (in Lithuanian, English abstr.).

Лазаричева, С.Г. 1988. Технология возделывания, уборки, хранения и использования рапса в Сибирии. *Новосибирск*. 40 pp. (in Russian).

Цыганов, А.Р**.** & Клочкова, О.С. 2006. Сравнительная эффективность применения гербицидов в посевах ярового рапса. *Агроэкология*, Горки. Труды БГСХА, вып. **4**, pp. 197–202. (in Russian).