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THE INFLUENCE OF WEED CONTROL ON WEED SEED RAIN IN SPRING BARLEY AND SPRING WHEAT CROPS

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Abstract

Field experiments were conducted during the period 2003–2005 at the Lithuanian Institute of Agriculture in the crops of spring barley cv. ʻLuokėʼ and spring wheat cv. ʻMunkʼ (2003–2004) and cv ʻZebraʼ (2005). Spring cereals were sown in the second half of April at a rate of 4.5 million seed ha^{-1} for spring barley and 5.0 million seed ha^{-1} for spring wheat. Herbicide Mustang (a. i. florasulam 6.25 g l^{-1} + 2.4 D ethylhexil ester 452.2 g l^{-1}) was spray-applied at the three leaf growth stage of cereals (BBCH 13) at 4 different rates: full rate – 0.6 l ha^{-1}, ¾ rate 0.45 l ha^{-1}, ½ rate 0.3 l ha^{-1}, ¼ rate 0.15 l ha^{-1}, and control (not sprayed). Weed seed rain was determined according to S. A. Rabotnov's method. When weeds started ripening, 10 troughs were arranged in a chess board order in groups in five places in spring cereals plots and were checked every two days. Collection of seeds was finished one day before harvesting. There were found 15 different weed species in the not sprayed spring cereal plots. *Chenopodium album* L., *Viola arvensis* Murray, *Galium aparine* L. and other short-lived species accounted for 68–95% of the total weed seed number found. Weed seed rain depended on weed control intensity and differed between spring barley and spring wheat stands.

Key words: weed seed, seed rain, spring barley, spring wheat, herbicide.

Introduction

Weeds are a permanent component of agro-ecosystems and remain the most important factor causing yield reduction. Efficient and timely weed control is one of the major tasks of competitive, intensive contemporary agriculture /Lemerle et al., 2001, Liebman, Staver, 2001, Sarrantonio, Gallandt, 2003/. Herbicides account for 20–30% of the total agricultural crops' cultivation costs in the world /Derksen et al., 2002/. The degree of control achieved by herbicides may vary widely depending on weed species present, soil type, climatic condition, and other factors. Because of the many factors involved, weed control often varies among locations and years /Derksen et al., 1993/. Weeds that escaped control produced seeds. The number of produced seed generally reflected the post cultivation densities of weeds /Forcella, 1995/. Seed production by uncontrolled weeds will increase seed banks substantially enough to lower yields in future years. Seed production is an important element of weed population dynamics /Cousens, Mortimer, 1995/. An understanding of seed production is essential for the development of improved weed management strategies /Norris, 2003/. The level of the weed seed production that allowed returning to the seed bank will affect the sustainability of any control strategy /Grundy et al., 2004/. There is considerable variability in seed production in some weed species between years because of climatic conditions /Mulugeta, Stoltenberg, 1998; Colquhoun et al., 2001/. It was established that up to 4543 seeds m^{-2} are shattered till harvesting of spring barley /Petraitis et al., 1993/. Leguizamon and Roberts found that application of soil herbicides reduced the numbers of weeds and the total seed output, but that of tolerant species was increased. Maximum numbers of seeds were 59,980 per m^2 for *Chenopodium album*, 39,430 per m^2 for *Stellaria media* and 37,580 per m^2 for *Veronica persica* Poiret /Leguizamon, Roberts, 1982/. The number of weed seeds depended on crop density, agrotechnics, meteorological conditions and soil characteristic /Petraitis et al., 1993/. Other researchers indicate that in the absence of weed control, the seed bank population growth followed a sigmoid curve. Control applied at random timing did not destroy a significant proportion of weed population /González-Díaz, 2007/.

Under Lithuanian conditions, in spring barley plots untreated with herbicide, weed seed rain begins at stem elongation stage and increases until the hard maturity stage. Of the total number of all shattered weed seeds from 5.8% to 22.7% are shattered till the medium milk stage, 26.6%–41.8% till late milk early-dough stage, 48.4%–90.6% – till dough stage /Pilipavičius, 2002 a/.

The aim of our research work was to establish weed seed rain as affected by weed control intensity in spring wheat and spring barley stands.

Materials and Methods

Field experiments were conducted during the period of 2003–2005 at the Lithuanian Institute of Agriculture in the crops of spring barley and spring wheat. The preceding crop for spring barley in 2003 and in 2005 was winter wheat, in 2004 spring wheat. The preceding crop for spring wheat in 2003 was spring barley, in 2004 spring rape, and in 2005 winter wheat. Spring barley cv. 'Luokė' was grown; spring wheat cv. 'Munk' was grown in 2003–2004, and in 2005 'Zebra'. Conventional soil tillage was used. The soil of the experimental site is *Endocalcary-Endohypogleyic Cambisol*, loam. In all experimental years spring cereals were sown in the second half of April. Spring barley was sown at a rate of 4.5 million seeds ha^{-1}, spring wheat at 5.0 million seeds ha^{-1}. Prior to sowing, the soil was fertilised with $N_{90} P_{90} K_{90}$ – ammonium nitrate, granulated superphosphate and potassium chloride were applied. Herbicide Mustang (a. i. Florasulam 6.25 g 1^{-1} + 2,4 D ethylhexil ester 452.5 g 1^{-1}) was spray – applied at the three leaf growth stage of spring cereals (BBCH 13), at different rates: full rate – 0.6 l ha^{-1}, ¾ rate 0.45 l ha^{-1}, ½ rate 0.3 l ha^{-1}, ¼ rate 0.15 l ha^{-1}, and control (not sprayed). The herbicide was applied using a compressed nitrogen gas bicycle sprayer with a 2.5 – meter wide boom, at 3.0 – bar pressure, nozzle 4110-12, and a spray volume of 200 l ha^{-1}.

Weed seed rain was determined according to S. A. Rabotnov's method. When weeds started ripening, 10 troughs (20 x 2 x 0.5cm) were arranged in a chess board order in groups in five places in spring cereal plots and were checked every two days. Collection of seeds was finished one day before harvesting.

In 2003 the weather was dry in May, June, and July, and August was wetter. In 2004 there was a shortage of moisture in May and June, while July and August were wetter, which delayed cereal harvesting. In 2005 the spring was wetter than in previous experimental years, while July was dry (hydrothermal coefficient 0.79), August was moderately wet compared with the long-term mean rainfall. Conditions for cereal growth in all experimental years were relatively good, only the droughty period of end of May–June of the year 2003 was less favourable.

Results and Discussion

The average weed seed rain in spring barley was twice as high as in spring wheat (Figures 1, 2).

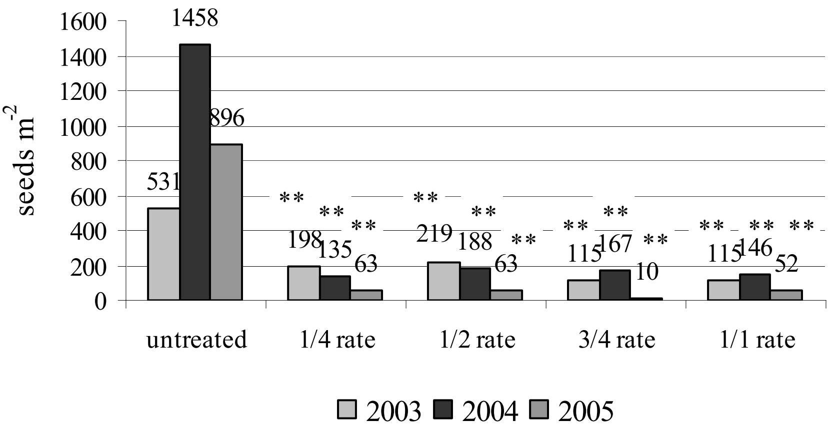


Figure 1. The amount of shattered weed seeds in spring barley, treated with different rates of herbicide. Dotnuva, 2003–2005

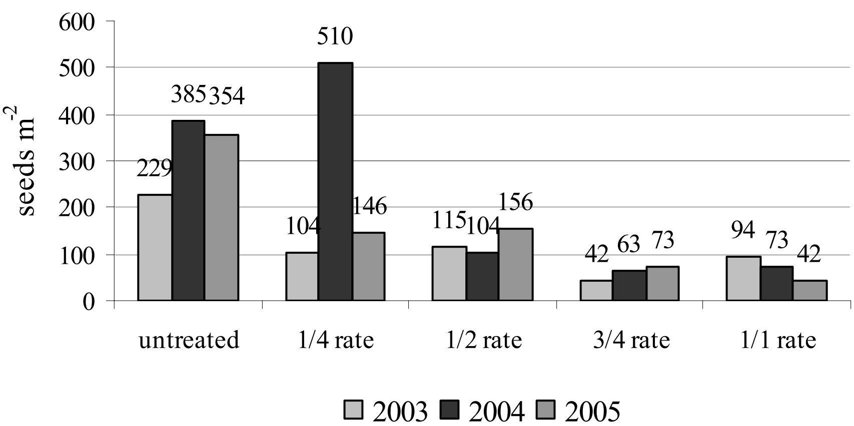


Figure 2. The amount of shattered weed seeds in spring wheat, treated with different rates of herbicide. Dotnuva, 2003–2005

In spring barley not sprayed with herbicides the weed seed rain amounted to 531–1458 seeds m^{-2} and in spring wheat from 230 to 533 seeds m^{-2}. In the spring barley plots sprayed with different rates of herbicide weed seed rain significantly declined. Weed seed rain in the herbicide – treated plots declined by 6.2–9.9 times compared with the untreated plots. The reduction in the number of shattered weed seeds in spring wheat sprayed with ¼ rate of herbicide was insignificant, and in the plots sprayed with ½ rate the seed rain decreased significantly at $P>0.05$ level compared with the not sprayed spring wheat. In spring wheat crop sprayed with ¾ and full rate the amount of shattered weed seeds was 5 times as low as that in the untreated plots. This suggests, that depending on the cereal species and its competitive ability, it is possible to use reduced herbicide rates. In all experimental years, there were found about 15 species of weed seeds, most of which were annual dicotyledonous, in spring cereals not sprayed with herbicide. The main species are presented in Figures 3, 4.

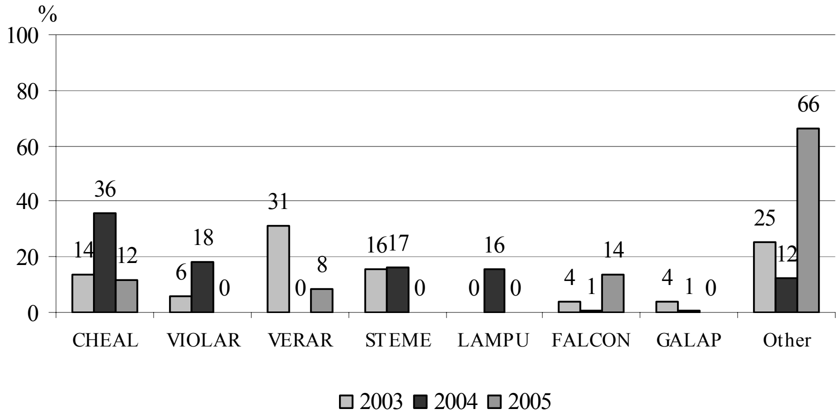
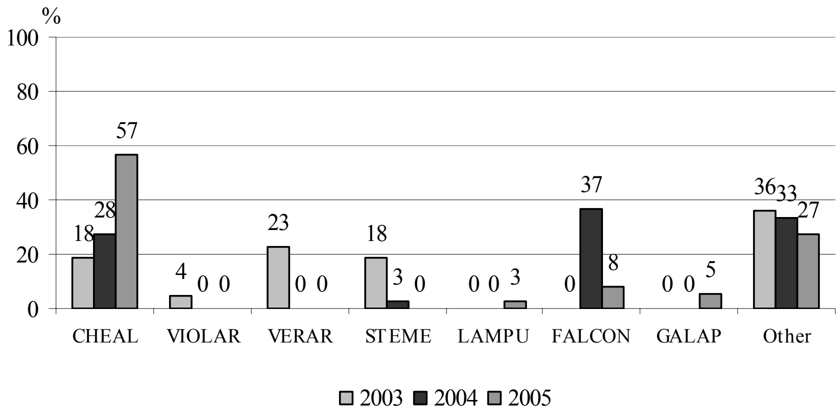


Figure 3. Weed seed species (%) found in spring barley crops



CHEAL* – *Chenopodium album,* VIOAR – *Viola arvensis,* VERAR – *Veronica arvensis,* STEME – *Stellaria media,* LAMPU – *Lamium purpureum,* FALCON – *fallopia convolvulus,* GALAP – *Galium aparine* (* – according to BBCH)

Figure 4. Weed seed species (%) found in spring wheat crops

Chenopodium album seeds were found in both crops of cereals. They accounted for 14–57% of the total seed number. Seeds of *Veronica arvensis, Stellaria media, Viola arvensis, and Fallopia convolvulus* were present in the seed rain. Short-lived weed species accounted for 68–95% of the total weed seed number found. The weed seed shattered from early milk stage to hard maturity stage of spring cereals. There were found some differences in seed rain between herbicide – treated and untreated plots also between spring barley and spring wheat crops.

In 2003, in the spring barley crops in the plots treated with full rate of herbicide about 80% of the total shattered weed seeds were found at milk stage of spring barley, whereas in spring wheat plots most of weed seeds were found at hard maturity stage (Figures 5, 6).

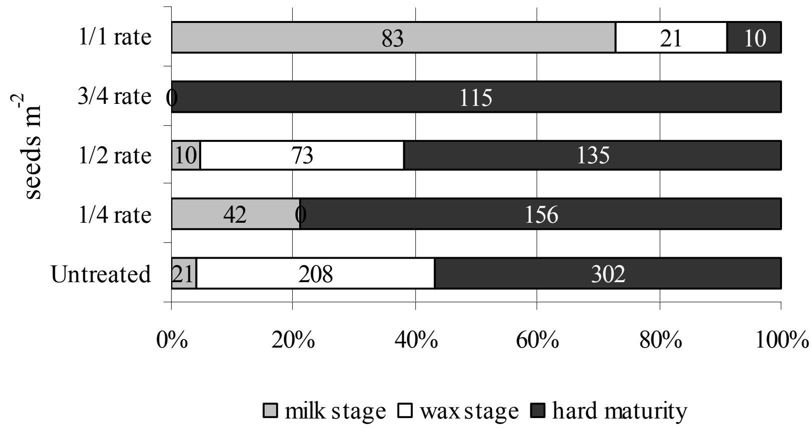


Figure 5. The proportion of shattered weed seeds m^{-2} in spring barley plots treated with different rates of herbicide. Dotnuva, 2003

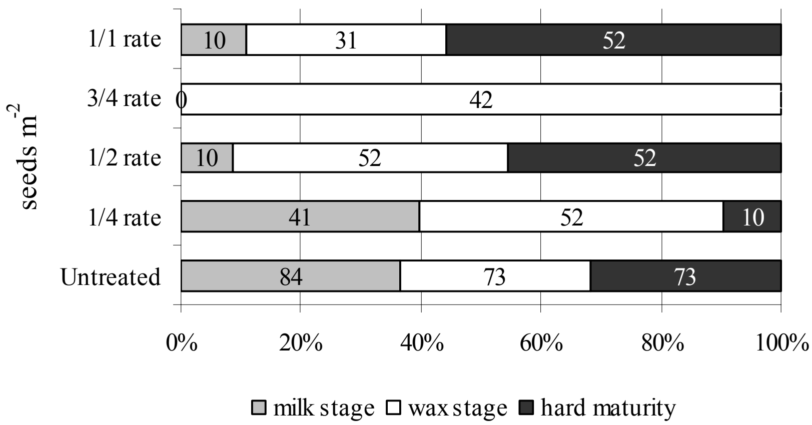


Figure 6. The proportion of shattered weed seeds m^{-2} in spring wheat plots treated with different rates of herbicide. Dotnuva, 2003

In spring barley plots untreated with herbicide and treated with low rates (1/4 and ½) more than half of the total shattered weed seed amount was found at hard maturity stage, whereas in spring wheat in the untreated and treated with ¼ rate of herbicide most of weed seeds were found at milk and wax maturity of spring wheat.

Similar data were obtained in 2004: the highest amount of weed seed was found at milk stage of spring barley in the plots sprayed with full rate of herbicide. The situation was different in spring wheat where almost all weed seeds shattered at hard maturity growth stage (Figures 7, 8).

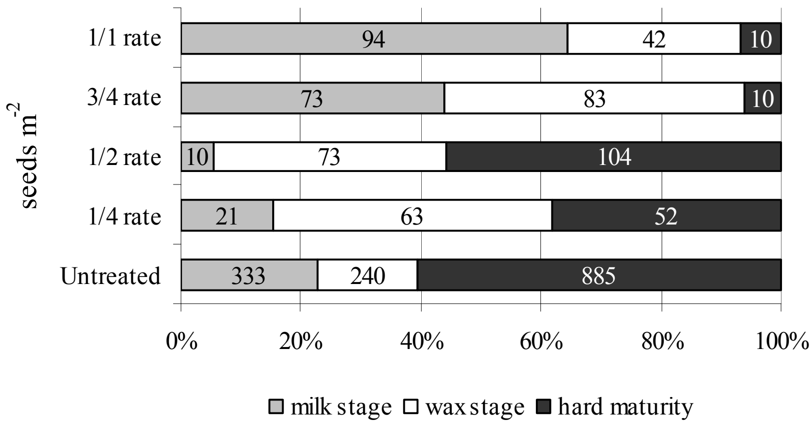


Figure 7. The proportion of shattered weed seeds m^{-2} in spring barley plots treated with different rates of herbicide. Dotnuva, 2004

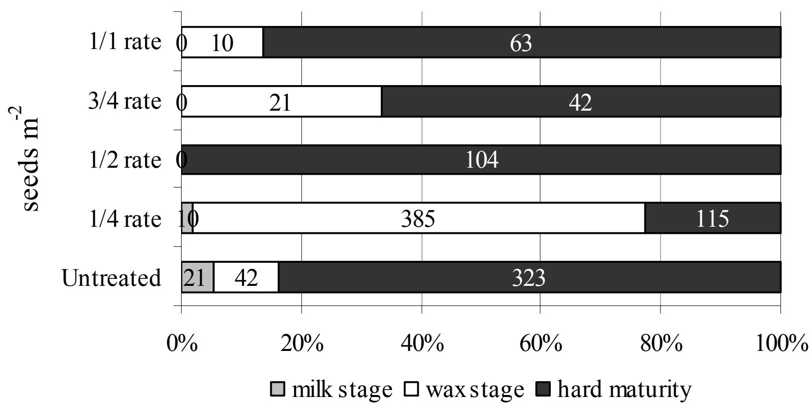


Figure 8. The proportion of shattered weed seeds m^{-2} in spring wheat plots treated with different rates of herbicide. Dotnuva, 2004

Competitive ability of spring cereals was responsible for the difference in the weed seed rain. Spring wheat has low competitive ability /Petraitis, Semaškienė, 2005/. Weeds that germinated after early (BBCH 12–13) weed control, i. e. the second flush of weeds, were able to mature seeds. Weed seed rain in 2005 differed from that in the other years (Figures 9, 10). In spring barley plots treated with full rate of herbicide weed seed rain occurred at hard maturity of barley.

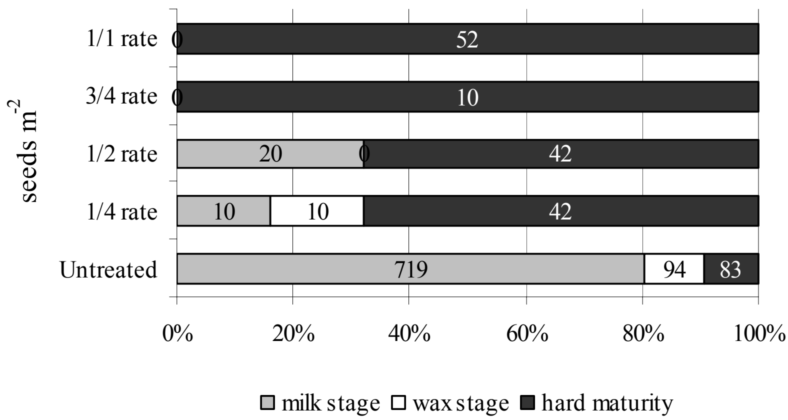


Figure 9. The proportion of shattered weed seeds m^{-2} in spring barley plots treated with different rates of herbicide. Dotnuva, 2005

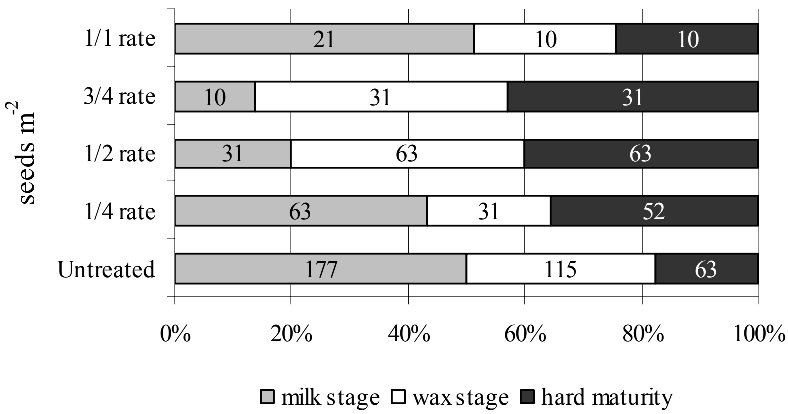


Figure 10. The proportion of shattered weed seeds m^{-2} in spring wheat plots treated with different rates of herbicide. Dotnuva, 2005

The differences between years might have been caused by the weather conditions. The second half of the growing season was dry with a hydrothermal coefficient of July of 0.79. Our results agree with those of Pilipavičius (2002), who found that weed seed rain depended on active air temperature and amount of rainfall /Pilipavičius, 2002 b/. Other researchers have reported that there is a considerable variability in seed production in some weed species between years because of the climate conditions /Mulugeta, Stoltenberg, 1998; Colquhoun et al., 2001/.

Conclusions

1. The greatest number of shattered weed seed was from short-lived species. The seed of *Chenopodium album* L., *Viola arvensis* Murray, *Galium aparine* L., *Stellaria media* L. Vill. and others accounted for 68–95% of the total weed seed number found.

2. The most abundant weed seed rain (299–1458 weed seeds m^{-2}) until harvesting occurred in spring cereals not sprayed with herbicides. In spring barley, in all treated plots weed seed rain was significantly lower than that in the untreated. Significant differences in weed seed rain were identified for spring wheat treated with ¾ and full doses of herbicide compared with the untreated.

3. The highest amount of weed seeds at milk stage of spring barley was determined in the plots sprayed with full rate of herbicide. The situation was different in spring wheat where almost all weed seeds were found at hard maturity stage. Weeds that germinated after weed control in spring wheat were able to produce seeds, and the seed rain occurred later.

4. Depending on the spring cereal species and competitive ability it is feasible to reduce herbicide application rate.

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