Chapter 7. BIOLOGICAL PEST AND WEED CONTROL

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WEED CONTROL IN SPRING BARLEY BY HARROWING

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Abstract

The effect of harrowing on annual dicotyledonous weeds at different growth stages of organically grown spring barley was investigated in the field trials conducted at the Lithuanian Institute of Agriculture over the period 2005–2007. Spring barley was harrowed by a flex-tine harrow according to the scheme: 1) control (not harrowed); 2) harrowed at spring barley pre-emergence; 3) harrowed twice: at spring barley pre-emergence and at 3–4 leaf stage; 4) harrowed three times: at spring barley pre-emergence, at 3–4 leaf stage, and at stem elongation stage; 5) harrowed at 3–4 leaf stage of spring barley, and 6) harrowed at spring barley 3–4 leaf stage and at stem elongation stage. The main weeds in spring barley stands were *Chenopodium album, Sinapis arvensis, Stellaria media, Tripleurospermum perforatum*, *Lamium purpureum, Viola arvensis*.

The decrease in weed number and mass in spring barley stands depended on weed species composition. The total number of weeds was by 83% lower at early milk stage of spring barley in 2005 and by 61% in 2007.

No statistical difference in spring barley grain yield was determined among the treatments.

Key words: spring barley, harrowing, weed number.

Introduction

In recent times, the reduction of pesticide use has become an important objective in agriculture and there has been increasing focus on organic farming. One of the key problems in organic farming is the effort required for weed control /Riemens et al., 2007/.

Interest exists not only in the use of weed management strategies aimed at the reduction of the soil weed seed bank to prevent large above ground weed communities /Norris, 1999; Sjursen, 2001/, but also in integration of preventive methods of weed management in organic or low – input growing system /Barberi, 2002/. Preventive methods like crop rotation /Bond, Grundy, 2001/, use of competitive species and varieties /Lemerle et al., 2001, Semaškienė et al., 2007/ can keep weed population in low densities.

Harrowing is a traditional form of mechanical weed control for dealing with annual weeds but is ineffective against perennial and established deep-rooted weeds. In cereals, "blind" or pre-emergence harrowing may be carried out after drilling but before crop emergence in order to kill the first flush of small emerging weeds /Rasmussen, Ascard, 1995/. Spring tines of the weed harrow control weeds by uprooting and/or covering small weed plants with soil. Post-emergence harrowing may also cause crop injury, but selectivity depends on many factors including the soil covering mechanism /Kurstjens, Perdok, 2000/. In situations with relatively large weed plants and relatively small crop plants, there are increased risks of crop damage by soil cover or other mechanical damages to the crop leaves. These damages are increasing with increasing weed control intensity, and result in reduced crop growth immediately after weed harrowing. There are risks that the reduced growth reduces final crop yield too. However, there is some evidence that there are varietal differences in the tolerance to weed harrowing and that tolerance is negatively correlated with competitiveness against weeds /Rasmussen et al., 2004; Hansen, 2005/.

Dry weather is critical to the success of early harrowing operations but adequate soil moisture is needed initially to encourage early weed emergence. Blind harrowing has little effect if few weeds have emerged, and may sometimes delay crop emergence /Heard, 1993/.

Mechanical weeding effectiveness is very time-sensitive and highly influenced by environmental conditions /Kurstjens, Kropff, 2001; Kurstjens, 2004/. Selectivity with rigid and with flexible tines could be improved when the crop had a size advantage over the weeds /Rasmussen, Svenningsen, 1995/ and the effect on the weeds depended on the species /Welsh et al., 1997; Auškalnienė, Lukošiūnas, 2003/.

The efficacy is unequal during all growing period: initially low efficacy increased due to weed mortality caused by non-favourable climatic conditions for the weeds during the cropping cycle after harrowing or by strong crop competition. Initially high efficacy decreased in some cases due to new germination stimulated by the harrowing /Cirujeda, Taberner, 2004/.

The aim of present work was to estimate the efficacy of different intensities weed harrowing on weed and spring barley grain yield.

Materials and Methods

Three field experiments were conducted in organically grown spring barley during 2005–2007 to investigate the influence of pre and post-emergence harrowing on weed number and weed mass and grain yield of spring barley. The preceding crop for spring barley was winter wheat. Spring barley variety 'Luokė' was grown; conventional soil tillage was used. The soil of the experimental site is *Endocalcary-Endohypogleyic Cambisol*, loam. In all experimental years spring barley was sown in the end of April, at a rate of 4.5 million seeds ha^{-1}.

Spring barley was harrowed by a flex-tine harrow according to the scheme: 1) control (not harrowed); 2) harrowed at spring barley pre-emergence stage; 3) harrowed twice: at spring barley pre-emergence stage and at 3–4 leaf stage; 4) harrowed three times: at spring barley pre-emergence stage, at 3–4 leaf stage and at stem elongation stage; 5) harrowed at 3–4 leaf stage of spring barley, and 6) harrowed at spring barley 3–

4 leaf stage and at stem elongation stage. The date of each harrowing is provided in Table 1.

Table 1. The date of harrowing in spring barley stands over the period of 2005–2007

Growth stages of spring barley at the time of harrowing	Date of harrowing / Year		
	2005	2006	2007
T1 – pre-emergence stage of barley	17th of May	12th of May	3rd of May
T2 – 3–4 leaf stage of barley (BBCH 13–14)	26th of May	24th of May	18th of May
T3 – beginning of stem elongation of barley (BBCH 31–32)	8th of June	12th of June	29th of May

One week after each harrowing the efficacy of harrowing was measured – weeds were counted in four places of each plot of spring barley.

Five weeks after the last harrowing weeds were pulled out from each plot's four $0.25m^{-2}$ subplots and counted, green mass of weeds was measured for each weed species separately. The grain yield of spring barley was harvested by a combine "Sampo" and adjusted to 15% moisture.

All data were analyzed using ANOVA from the package SELEKCIJA /Brewbaker, 1995; Tarakanovas, Raudonius, 2003/. To achieve homogeneity of variance, the weed biomass data were Sqr(X+1) transformed.

Results and Discussion

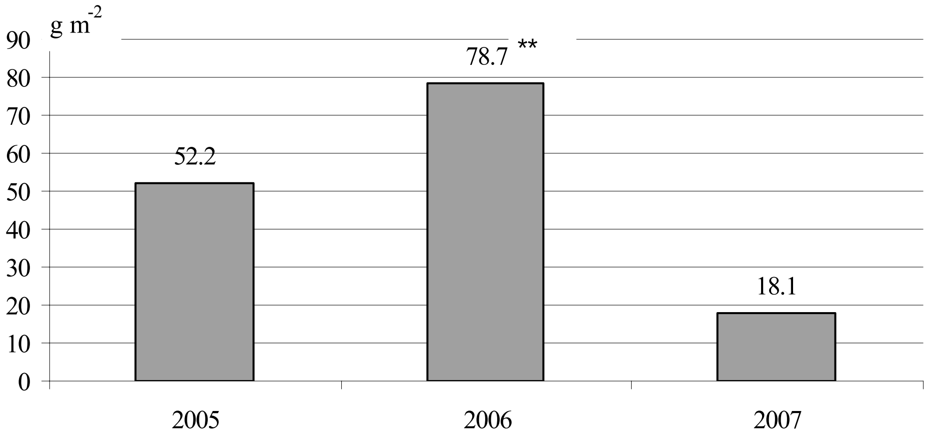
The main weeds in spring barley stands in 2005 and 2007 were annual dicotyledonous: *Chenopodium album*, *Sinapis arvensis*, *Tripleurospermum perforatum. Sonchus arvensis* prevailed in spring barley stands in 2006. Weed botanical composition and number per m^2 is shown in Table 2.

Table 2. Weed number per m^2 and botanical composition in non-harrowed spring barley stands

Dotnuva, 2005–2007

Weed species	Weed number /Year		
	2005	2006	2007
Chenopodium album	39.3	6.5	56.8
Euphorbia helioscopia	0.0	0.3	0.0
Sinapis arvensis	5.5	0.0	0.0
Lamium purpureum	0.8	1.0	0.0
Viola arvensis	0.0	0.3	3.0
Tripleurospermum perforatum	0.8	0.0	0.3
Fallopia convolvulus	0.0	0.5	1.5
Sonchus arvensis	0.0	25.0	0.0
Other	5.6	6.3	10.0
Total	51.8	39.8	71.5

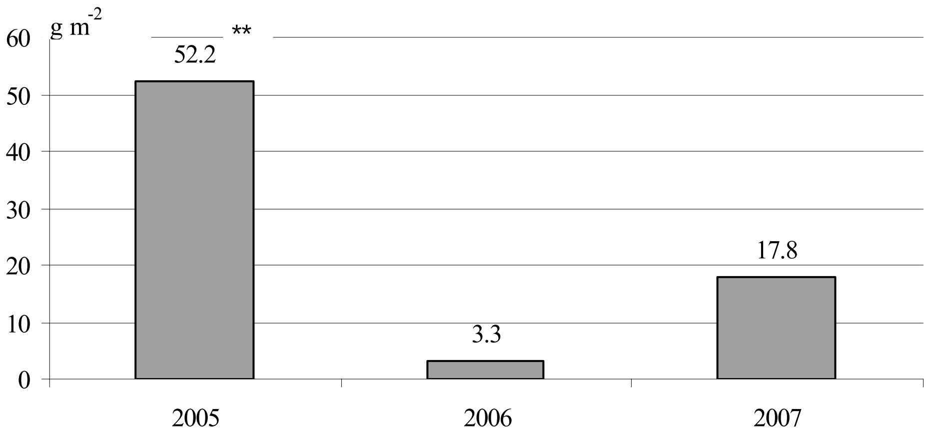
Total weed biomass was significantly higher ($P< 0.0001$) in 2006 than in 2005 and 2007 in the non-harrowed spring barley plots (Figure 1).



**difference significant at 99% probability level

Figure 1. The weed biomass in non-harrowed spring barley plots

Perennial weeds – *Sonchus arvensis* and *Cirsium arvense* accounted for more than 90 percent of the total weed biomass in 2006. The higher amount of annual weeds in non-harrowed plots was found in 2005 (Figure 2).



**difference significant at 99% probability level

Figure 2. The mass of annual weeds in non-harrowed spring barley

One week after each harrowing weeds were counted in spring barley plots. The highest decrease in weed number one week after harrowing was found in three-times harrowed plots. The weed number found in three-times harrowed spring barley plots was 4.8–9.6 times lower, than in non-harrowed plots (Figure 3).

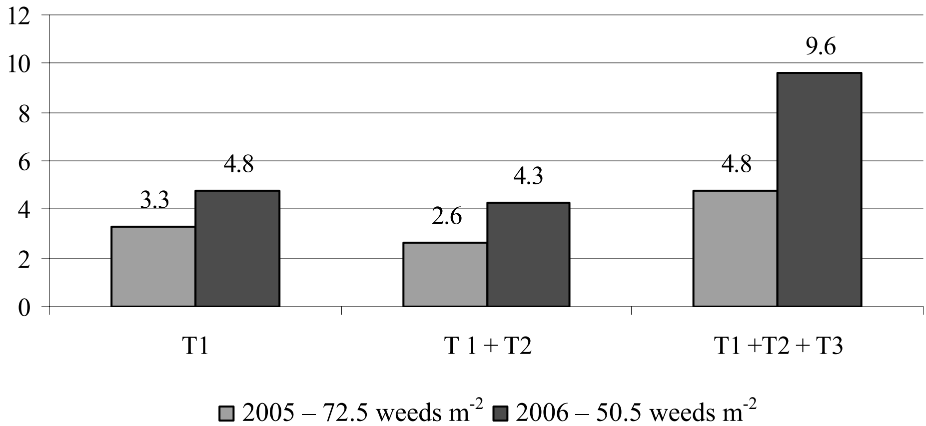


Figure 3. The decrease of weed number shortly after the last harrowing (T3)

Initially high efficacy decreased in some cases due to new germination stimulated by the harrowing /Cirujeda, Taberner, 2004/. As a result, the decrease in weed number found at the last evaluation was not so high; however, weed number in harrowed plots was significantly lower than in non-harrowed (Table 3).

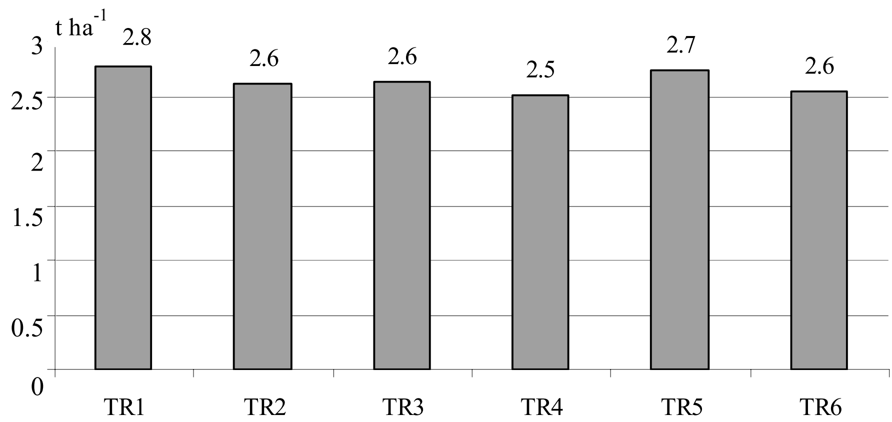
Table 3. The influence of harrowing time and density on the number of weeds in spring barley stands 5 weeks after the last harrowing. Dotnuva, 2005–2007

Year	Weeds m^{-2}					
	Not harrowed	T1	T1 + T2	T1 + T2 + T3	T2	T2 + T3
2005	51.8	30.0	11.2**	8.8**	22.2*	18.8**
2006	14.0^{o}	1.5**	1.9**	0.7**	4.8**	1.6**
2007	71.5	62.8	47.5	30.8*	46.5	27.8*

^{o} – mass of annual weeds
T1 – harrowed at pre-emergence stage of barley, T2 – at 3–4 leaf stage of barley (BBCH 13–14), T3 – at the beginning of stem elongation of barley (BBCH 31–32).
*difference significant at 95% probability level; **at 99%

In most cases the first early harrowing (T1) was more effective, than the first later harrowing (T2). This confirms the proposition that mechanical weed control becomes difficult after the cotyledon stage and its selectivity decreases with increasing weed age /Melander, 1997; Kurstjens et al., 2000; Kurstjens, Kropff, 2001/. The main cause of mortality was different for different weed species: *Chenopodium album*, *Sinapis arvensis*, *and Tripleurospermum perforatum* were sensitive to harrowing. Low efficacy was found for perennial weeds. This agrees with the findings of previous studies /Cirujeda et al., 2003; Auškalnis, Auškalnienė, 2006/.

There were not found any significant differences in spring barley grain yield between the treatments (Figure 4). This indicates that spring barley crop damage through harrowing was not significant.



TR1 – non-harrowed; TR2 – at spring barley pre-emergence stage (T1); TR3 – harrowed twice: T1 and 3–4 leaf of spring barley (T2); TR4 – harrowed three times: T1, T2 and at stem elongation stage of barley; TR5 – T2; TR6 – T2 and T3

Figure 4. The grain yield of spring barley in different treatments of harrowing. Mean data of 2005–2007

Conclusions

1. The main weeds in spring barley stands were annual dicotyledonous: *Chenopodium album*, *Sinapis arvensis*, *Tripleurospermum perforatum.* Perennial weeds were prevalent in spring barley stands in 2006.

2. Shortly after harrowing, weed number decreased 4–9 times compared to the non - harrowed plots. Initially high efficacy decreased due to the germination of new weeds, stimulated by harrowing.

3. There were not found any significant differences in spring barley grain yield in harrowed and non-harrowed plots.

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