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Influence of *Heracleum sosnowskyi* control measures on weed diversity in agricultural fields in Latvia

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Abstract: In a field infested with *Heracleum sosnowskyi*, plots were cultivated by disc harrow or ploughed in 2003 and then sown with one of two grass mixtures. Half of the grass plots were sprayed once with a herbicide containing MCPA, fluroxypyr and chlorpyralid; the other half were cut 3 times with a hand mower. In 2004 a similar trial was established after an early season application of glyphosate to control *Elymus repens* and the soil had been deep ploughed. The most effective control of *H. sosnowskyi* and *E. repens* was obtained by glyphosate application after spring regrowth followed by deep ploughing. This treatment did not adversely affect either numbers of dicotyledonous species or numbers of dicotyledonous plants that grew in the sown grass swards. Ploughing gave better control of *H. sosnowskyi* and *E. repens* than disc harrowing and provided better seedbeds for sward establishment. Ploughing also increased the numbers of dicotyledonous species and plants compared to disc harrowing. Chemical weed control reduced diversity and plant numbers, but weed control by cutting did not.

Key words: *Heracleum sosnowskyi*, weed diversity, soil cultivation, herbicide, cutting

INTRODUCTION

Heracleum sosnowskyi is a persistent and invasive weed in some fields where it was previously grown as a fodder crop. The trials described here were located in the Gauja National Park, in a farmer's field that had not been cultivated for the previous 5 years. The aim at this agricultural site was to restore the grassland and encourage the growth of native dicotyledonous species within the sward after *H. sosnowskyi* control by combining several approaches, using different soil cultivations and different sown grass mixtures, and chemical and mechanical weed control. The ability of the sown grass swards to suppress the growth of *H. sosnowskyi* was assessed, together with the effects of the treatments on the range of species and numbers of plants.

MATERIALS AND METHODS

The field selected for the three trials was heavily infested with *H. sosnowskyi* (25-30 plants m^{-2}). In 2003, two trials of 5 treatments in 6 replicates were laid out in adjacent strips (plots 10 m x 3 m). In one trial all plots were cultivated by disc harrow; in the other trial unsown plots were cultivated by disc harrow, and plots to be sown with grass were ploughed. Grass plots were sown by seeder (on 13 May) with one of two mixtures at a high seed rate (4,000 germinated seeds m^{-2}):

mixture 1: *Dactylis glomerata* (50%), *Festuca rubra* (50%)

mixture 2: *Lolium perenne* (12%), *Festuca rubra* (35%), *Poa pratensis* (53%).

For chemical weed control the herbicide Ariane (MCPA 54 g L^{-1} + fluroxypyr 27 g L^{-1} + chlorpyralid 267 g L^{-1}) was applied once at 2.75 L ha^{-1} to half of the grass plots, on 11 June. For mechanical weed control half of the grass plots were cut three times by hand mower: 11 June, 9 July and 11 August. Plant numbers of all species were recorded in the same 3 quadrants (0.25 m^{-2}) in each plot on 11 June, 9 July and 11 August. In 2004 nitrogen fertiliser (52 kg ha^{-1}) was applied on 30 March to all plots in the two trials laid down in 2003. All plots in the disc harrow trial were cut by hand mower three times: 7 May, 1 June and 14 July. Plant numbers were recorded on 6 May and 6 July. All plots in the ploughed trial were cut once by hand mower on 6 May. The herbicide Ariane was applied to the chemical weed control plots on 1 June. The mechanical weed control plots were cut by hand mower on 1 June, 29 June, 15 July, 29 July and 23 August. Plant numbers were recorded on 6 May, 6 July and 1 September.

Because *Elymus repens* had appeared as a dominant species in the 2003 trials, the site of a trial established in 2004 was sprayed with Roundup Gold (glyphosate 450 g L^{-1}) at 4.8 L ha^{-1} on 6 May, when there had been substantial spring growth (*H. sosnowskyi* 3-36 cm; *E. repens* up to 23 cm). The site was ploughed to a depth of 24 cm on 30 May and the 2003 grass mixtures sown in the treated plots on 1 June. No chemical control was applied in this trial because there was no regrowth of old plants or new germination of seedlings of *H. sosnowskyi*; mechanical weed control plots were cut once by hand mower on 19 July. Plant numbers were recorded on 19 July and 1 September.

The data were subjected to analysis of variance for randomised block designs using GenStat for Windows. Shannon diversity index values (a combined measure of species richness and abundance) were calculated for treatments, averaged over replicates, by the method described by Magurran (1988) using natural logarithms.

RESULTS AND DISCUSSION

Disc-harrowing alone produced a poorer seed-bed which had an adverse effect on germination and establishment of the sown grass mixtures and may also have reduced the survival of some species during a period of hot, dry weather later in 2003. The direct effect of the soil cultivations and the poor establishment of the sown grasses allowed *E. repens* to become dominant in the disc-harrowed trial early in the growing season. Most *H. sosnowskyi* plants grow from seed: 28–34 plants m^{-2} in the untreated plots, compared with 4–5 plants m^{-2} that regrew from roots.

Table 1. Mean numbers of dicotyledonous species excluding *H. Sosnowskyi.*

	Disc harrowed trial						Ploughed trial					
	UnT	G1C	G1M	G2C	G2M	LSD	UnT	G1C	G1M	G2C	G2M	LSD
Jun-03	6.8	8.0	7.2	8.3	7.3	2.05	10.7	15.0	16.3	14.2	16.3	2.97
Jul-03	9.0	3.8	7.5	5.5	8.8	2.81	10.8	11.2	17.8	10.8	17.7	3.88
Aug-03	8.2	6.0	10.8	8.0	9.2	1.95	8.5	10.8	17.3	10.5	16.5	2.71
May-04	5.0	2.8	5.7	2.8	5.5	1.31	5.3	4.5	7.8	3.7	7.0	1.54
Jul-04	7.0	6.2	6.5	6.0	6.2	1.52	9.8	1.3	8.3	1.0	6.8	2.08
Sep-04	-	-	-	-	-	-	6.2	0.2	7.5	0.8	6.0	1.60

G1, G2: Grass mixture 1, 2; C: Chemical weed control; M: Mechanical weed control; LSD 5%

Ploughing greatly reduced the numbers of *H. sosnowskyi* plants, from 39 m^{-2} in the untreated (disc harrowed) plots of the ploughed trial to 6–8 m^{-2} in the ploughed plots at the first assessment. The numbers of dicotyledonous species recorded at the first assessment, 29 days after sowing the grass mixtures, were higher in the ploughed trial than in the corresponding plots in the disc-harrowed trial (Table1). In the ploughed trial, the numbers of species in the plots that had been ploughed and sown with grass were significantly higher than in the untreated plots that had been cultivated only by disc-harrow. The numbers of dicotyledonous species were consistently lower at the start of the 2004 growing season than in 2003. Mechanical weed control had no effect on the numbers of species, but chemical weed control significantly reduced the numbers of species, especially in the ploughed trial in the second year. At the assessment before the first weed control treatments were applied, the dominant dicotyledonous species in all plots in the disc-harrowed trial were (in reducing order of abundance): *Taraxacum officinale, Vicia cracca, Sonchus arvensis, Ranunculus repens, Artemisia vulgaris* and *Achillea millefolium*. The predominant species in the ploughed trial were different in the untreated and treated plots; untreated plots: *Taraxacum officinale, Ranunculus repens, Thlaspi arvense, Artemisia vulgaris, Lamium purpureum* and *Achillea millefolium*; treated plots: *Lamium purpureum, Thlaspi arvense, Fumaria officinalis, Chenopodium album, Stellaria media* and *Taraxacum officinale*.

The numbers of dicotyledonous plants at the first assessment were significantly higher in the plots that had been ploughed and sown with grass than in the other plots (Table 2). Chemical weed control significantly reduced the numbers of plants compared with the corresponding grass sown plots in both trials. The numbers of plants in the mechanical weed control plots increased through both growing seasons in the disc-harrowed trial but only in the second year in the ploughed trial. The decline at the third assessment in the first year was largely accounted for by reductions in the numbers of *Thlaspi arvense* and *Fumaria officinalis*, which are early flowering species.

No *H. sosnowskyi* plants were recorded in the trial established in 2004 after glyphosate treatment and deep ploughing. *E. repens* stems accounted for only 5% of the total plant population. The numbers of dicotyledonous species and the numbers of dicotyledonous plants were both higher than in the 2003 trials (Table 3).The predominant species were similar in both the untreated plots and the grass sown plots (*Lamium purpureum, Taraxacum officinale, Fumaria officinalis, Sonchus arvensis, Thlaspi arvense*), but *L. purpureum* was even more dominant in the grass plots (47.5% of dicotyledonous plants) than in the untreated plots (36.7% of dicotyledonous plants).

The decline of plant numbers at the September assessment again reflects natural senescence of early flowering annual species.

Table 2. Mean numbers of dicotyledonous plants m^{-2} excluding *H. sosnowskyi.*

	Disc harrowed trial						Ploughed trial					
	UnT	G1C	G1M	G2C	G2M	LSD	UnT	G1C	G1M	G2C	G2M	LSD
Jun-03	81.3	93.8	64.0	72.2	71.3	28.43	62.7	146.9	144.2	178.4	170.7	75.35
Jul-03	93.6	39.1	100.4	38.7	118.7	38.57	74.4	65.8	143.1	69.3	164.2	49.85
Aug-03	95.6	59.1	118.9	64.0	148.2	34.99	73.3	56.7	113.1	48.7	116.0	31.95
May-04	57.6	47.6	88.2	49.8	89.8	32.55	61.3	9.8	34.0	14.7	33.1	16.79
Jul-04	93.6	56.4	108.9	50.9	88.2	24.58	71.8	2.7	51.1	1.3	50.2	15.98
Sep-04	-	-	-	-	-	-	38.0	0.2	104.7	1.3	110.2	31.11

Table 3. Mean numbers of dicotyledonous species and plants m^{-2} excluding *H. sosnowskyi* in the glyphosate ploughed trial established in 2004.

	Mean numbers of species						Mean numbers of plants m^{-2}					
	UnT	G1	G1M	G2	G2M	LSD	UnT	G1	G1M	G2	G2M	LSD
Jul-04	18.2	16.2	15.7	15.3	16.7	2.30	172.0	184.1	167.4	159.3	175.6	70.27
Sep-04	18.0	19.8	16.3	16.2	16.5	2.05	131.6	106.7	109.3	79.1	72.1	23.44

The Shannon diversity index values for the ploughed trial were consistently higher than those for the disc-harrowed trial, by an average of 67% (Table 4). The values in the second year in both trials were lower than in the first year, by 39% and 23% respectively. Chemical weed control in grass mixture 1 severely reduced the diversity index in the ploughed trial in the second season. The index values for the trial established after glyphosate treatment and deep ploughing were very similar to those in the first season of the ploughed trial, but increased by 27% by the end of the season.

Table 4. Shannon diversity indexes for dicotyledonous species excluding *H. sosnowskyi*.

	Disc harrowed trial					Ploughed trial				
	UnT	G1C	G1M	G2C	G2M	UnT	G1C	G1M	G2C	G2M
Jun-03	1.44	1.40	1.67	1.67	1.76	2.51	2.33	2.44	2.25	2.38
Jul-03	1.54	1.07	1.55	1.43	1.73	2.37	2.31	2.70	2.30	2.63
Aug-03	1.67	1.46	1.84	1.61	1.67	2.04	2.49	2.78	2.39	2.78
May-04	0.83	0.43	0.85	0.57	0.78	1.52	2.19	2.04	1.92	2.03
Jul-04	1.32	1.46	1.04	1.16	1.17	2.07	1.55	1.92	1.56	1.93
Sep-04	-	-	-	-	-	1.82	0.00	1.27	1.01	1.14
	Glyphosate & ploughed trial									
	UnT	G1	G1M	G2	G2M					
Jul-04	2.46	1.85	1.95	2.37	2.19					
Sep-04	2.73	2.82	2.66	2.79	2.75					

CONCLUSIONS

The most effective control of *H. sosnowskyi* and *E. repens* was obtained by the application of glyphosate after spring regrowth followed by deep ploughing. This treatment did not adversely affect either numbers of dicotyledonous species or numbers of dicotyledonous plants that subsequently grew in the sown grass swards. Ploughing substantially reduced densities of *H. sosnowskyi* and *E. repens* and provided good seedbeds for sward establishment. Disc harrowing gave little control of *H. sosnowskyi* and reduced soil disturbance did not promote growth of the indigenous flora. Chemical weed control reduced diversity and plant numbers, but weed control by cutting did not.

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