Perennial weed control by two layer ploughing

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Abstract. Experiments on methods of perennial weed control were carried out at the Kazliškiai organic farm of Lithuanian University of Agriculture in the period 2002-2003. The aim of the work was to investigate the influence of conventional 'cultural' cylindrical and two-layer plough technologies on perennial weed control in organic agriculture. The advantage of two-layer ploughing in decreasing perennial weed density and biomass in spring wheat and buckwheat crop was established. *Elytrigia repens, Cirsium arvense, Tussilago farfara* and *Plantago major* density and biomass had a tendency to decrease in different years of the trial.

Keywords: perennial weeds, weediness, organic agriculture, two layer ploughing

INTRODUCTION

Despite differences in farm size, historical background and other factors, there are concentrations of a few perennial and annual weeds that occur in almost all new EU member countries. These are, above all, *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) Gould., *Chenopodium album* L., *Galium aparine* L., and different chamomile species. These species are not restricted to organic farming and are very common in conventional farming too (Glemnitz, 2007). Conventionally, in cereal crops annual weeds predominate, whereas, by contrast in organic agriculture, perennial weed plants develop better, are stronger and grow more biomass (Pilipavičius, 2005). *Cirsium arvense* L. (Scop.) is one of the major perennial weeds found throughout temperate zones. Because of its widely ramified and deep root system, up to three meters long, mechanical control of *Cirsium arvense* is often inefficient (Niederstraßer et al., 2007). Sometimes it is difficult to investigate treatment effects on *Cirsium arvense* or other perennial weed species because their abundance is often low (Verschwele, 2007). The dynamics of perennial weed species (e.g. *Elytrigia repens* and *Rumex obtusifolius*) must be carefully evaluated, especially for farming systems combining extensive management in terms of pesticide use and a reduction of soil-tillage intensity (Hiltbrunner et al., 2008). Perennial weeds, such as *Cirsium arvense*, represent an extensive challenge in organic cereal production systems. Different strategies are recommended for the control of this weed (Thomsen & Brandsæter, 2007). Successful physical control of perennial weeds may be enhanced by knowledge about how different factors affect their survival and regrowth. Among these factors are tillage or other mechanical control methods and the resulting fragment size of reproductive underground organs (Vanhala & Salonen, 2007). The method of two-layer ploughing was suggested for *Elytrigia repens* and *Cirsium arvense* control. A very strong dependence of *Elytrigia repens* rootstock and *Cirsium arvense* root insertion depth and regrowth ability was established. It was affirmed that qualitative and deep upper layer turning of arable soil into the bottom of a furrow (depth of 20 cm) decreases regrowth of *Elytrigia repens* and *Cirsium arvense* compared with shallow incorporation (depth of 5 cm, 10 cm and 15 cm) of their vegetative propagation rudiments (Lazauskas & Pilipavičius, 2004). A one year vegetation field experiment in Norway studying regeneration of *Cirsium arvense* from soil depths of 0, 10, 20, 30 and 40 cm showed that within each of the two main factors, time and soil depth, significant differences were detected in the number of shoots ($P < 0.05$). However, after approximately two months, the number of shoots from 30 cm and 40 cm soil depth was not significantly different from the number of shoots from the other treatments. It was concluded that the deeper root system of *Cirsium arvense* represents a threat for infestation of cropland and combined measures are needed to avoid infestation (Thomsen & Brandsæter, 2007). Root fragmentation of *Sonchus arvensis* L. to smaller pieces in autumn and burying them deeper reduces the initial shoot biomass of *Sonchus arvensis* plants in spring. To utilize the control potential of this approach, it would be beneficial to develop machinery and techniques that allow – besides strong fragmentation – determination of the burial depth of roots (Vanhala & Salonen, 2007).

The aim of the work was to investigate the influence of conventional 'cultural' cylindrical and two-layer plough technologies on perennial weed control in organic agriculture.

MATERIALS AND METHODS

The field trial was carried out at the Kazliškiai organic farm of the Lithuanian University of Agriculture in the period 2002–2003 on PLb-g4 *Eutric Planosol Endohypogleyi PLe-gln-w* soil. The buckwheat crop (2003) followed spring wheat (2002) which was sown after spring barley (2001). There were four replications in the trial fields. The agrochemical characteristic of arable soil was determined at the Experimental Station of the Lithuanian University of Agriculture using a computer system PSCCO/ISI IBM-PC 4250. Agrochemical indications of arable soil (0-25 cm layer) were as follows: humus 3.34%, pH 6.8, P_2O_5 177 mg kg^{-1} and K_2O 116mg kg^{-1}. In the field experiment, two types of plough on perennial weed control in organic agriculture were compared, a conventional 'cultural' cylindrical PLN-3-35 plough without skim-jointers and a two-layer plough PJa-3-35. Ploughing depth for both types of plough was 20 cm. Weed samples for estimation of crop weediness were taken from each plot of the trial at III ten-day periods of June for spring wheat and at II ten-day periods of July for buckwheat in 10 places using a frame of 50 x 50 cm and were air-dried. The trial data were evaluated using analysis of variance by 'Selekcija' (Tarakanovas, 1999).

RESULTS AND DISCUSSION

Evaluating perennial weed control efficiency by ploughing in crops of spring wheat and buckwheat it was confirmed that ploughing with a two-layer plough decreases crop weediness more than with a cylindrical plough. After ploughing with a two-layer plough, total weed number decreased by 22% in spring wheat and 17% in buckwheat and air-dry biomass by 33% in spring wheat and 36% in buckwheat relative to plots ploughed with a 'cultural' cylindrical plough (Table 1). During two years of experimentation, there were an estimated 41 weed species, 26 annual and 15 perennial. In the crop of spring wheat, 37 weed species were established, 22 annual and 15 perennial. In the second year of the experiment, in the buckwheat crop, there were 36 weed species: an increase of 26 annual and 10 perennial species (Table 1). The experimental field had an unusual composition of perennial and annual weeds. In the spring wheat crop, perennial weeds dominated: 59%–71% of the total weed number and 81%–93% of total weed air-dry mass in plots ploughed by two-layer and 'cultural' cylindrical ploughs, respectively (Table 1). Similarly, in the second year of the experiment, this composition continued in the buckwheat: 57%–77% of total weed number and 85%–95% of total weed air-dry mass. This shows that annual weeds were highly suppressed not by the crop plants but especially by the perennial weeds. As a consequence, crop weediness increased by 57 weeds m^{-2} and 239 g m^{-2} in plots ploughed with the 'cultural' cylindrical plough and by 51 weeds m^{-2} and 150 g m^{-2} in plots ploughed with the two-layer plough i.e. by 6 weeds m^{-2} and 89 g m^{-2} less (Table 1).

In the crops of spring wheat and buckwheat, the perennial weeds *Elytrigia repens, Cirsium arvense, Sonchus arvensis, Tussilago farfara* and *Plantago major* dominated while the annual weeds, the most widespread of which were *Chenopodium album, Capsella bursa-pastoris* and *Stellaria media,* were in recessive position. *Cirsium arvense* comprised 56%–67% of the total perennial weed air-dry mass in plots ploughed with the 'cultural' cylindrical plough and decreased by 25%–34% in plots ploughed with the two-layer plough in crops of spring wheat and buckwheat, respectively. There was established a regular decrease of *Cirsium arvense* air-dry mass from 43–205 g m^{-2} to 11–60 g m^{-2}, respectively. The second dominant perennial weed *Sonchus arvensis* comprised 35%–28% of the total perennial weed air-dry mass in plots ploughed with 'cultural' cylindrical plough and increased by 56%–54% in plots ploughed with the two-layer plough in crops of spring wheat and buckwheat, respectively. Evaluating the dynamics of change of *Sonchus arvensis* in absolute dimension there was established a tendency to persist but not increase in *Sonchus arvensis* air-dry mass of 27–87 g m^{-2} to 27–94 g m^{-2}, respectively (Table 1). Consequently, the dynamics of change of *Sonchus arvensis* in the crop perennial weed composition was induced more by the decrease in the population of *Cirsium arvense* than by the applied treatment. Other dominant perennial weeds, *Elytrigia repens, Tussilago farfara* and *Plantago major,* in the crops of spring wheat and buckwheat mostly decreased in number and biomass in plots ploughed with the two-layer plough compared with the cylindrical one. However, *Elytrigia repens, Tussilago farfara* and *Plantago major* as well as *Sonchus arvensis* have a tendency to increase in number and biomass when continuing the field experiment on the same plot. This tendency remained for the annual, perennial and total weed number and biomass change from the spring wheat (2002) to the buckwheat (2003) crop. Nevertheless, the advantage of the two-layer plough, in decreasing perennial weed density and biomass in the spring wheat and the buckwheat crop was established in evaluating crop weediness in different years of the experiment when compared with the cylindrical plough.

Table 1. Spring wheat (2002) and buckwheat (2003) crop weediness (weed number m^{-2} and weed air-dry mass g m^{-2}) dynamics after ploughing with 'cultural' cylindrical and two-layer plough, LUA Kazliškiai organic farm 2002–2003.

Weed species	Types of ploughs							
	'Cultural' cylindrical				Two-layer			
	Crop							
	spring wheat		buckwheat		spring wheat		buckwheat	
	Weed number weed m^{-2}	Weed air-dry mass g m^{-2}	Weed number weed m^{-2}	Weed air-dry mass g m^{-2}	Weed number weed m^{-2}	Weed air-dry mass g m^{-2}	Weed number weed m^{-2}	Weed air-dry mass g m^{-2}
Chenopodium album L.	10.4	2.2	3.9	2.1	15.6	7.4	4.0	3.4
Capsella bursa-pastoris (L.) Medik	1.2	1.1	5.9	2.2	0.5	0.1	8.0	4.4
Crepis tectorum L.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.01
Euphorhia helioscopia L.	0.2	0.01	0.4	0.1	0.4	0.04	0.8	0.1
Erysimum cheiranthoides L.	0.1	0.01	0.6	0.2	0.01	0.01	0.7	0.2
Echinochloa crus-galli (L.) Beauv.	0.0	0.0	0.4	0.4	0.0	0.0	0.4	0.2
Fallopia convolvulus (L.) A. Löve	0.2	0.03	1.5	0.2	0.3	0.1	1.8	0.3
Fumaria officinalis L.	0.0	0.0	0.0	0.0	0.01	0.001	0.2	0.01
Galeopsis anfara L.	0.03	0.001	0.1	0.02	0.04	0.01	0.2	0.02
Galinsoga parviflora Cav.	0.01	0.001	0.1	0.01	0.0	0.0	0.0	0.0
Galium aparine L.	0.01	0.001	0.1	0.01	0.1	0.01	0.3	0.1
Lamium purpureum L.	0.1	0.004	1.0	0.1	1.1	0.1	5.3	1.9
Myosotis arvensis L.	0.0	0.0	0.1	0.1	0.01	0.001	0.1	0.01
Poa anua L.	0.2	0.02	1.6	0.1	0.1	0.01	0.6	0.1
Polygonum aviculare L.	0.6	0.1	1.4	1.1	0.5	0.1	2.5	1.2
Polygonum lapathifolium L.	0.1	0.01	0.1	0.01	0.2	0.1	0.1	0.04
Raphanus raphanistrum L.	0.1	0.1	1.2	1.6	0.4	0.8	1.3	1.7
Rorippa spp. L.	0.0	0.0	1.5	0.8	0.0	0.0	0.2	1.1
Sinapis arvensis L.	1.6	1.6	0.2	1.8	1.8	1.5	0.9	11.2
Spergula arvensis L.	0.0	0.0	0.1	0.01	0	0	0.1	0.01
Stellaria media (L.) Vill.	2.8	1.0	8.6	3.6	1.8	0.5	14.4	4.0
Thlapi arvense L.	0.2	0.01	0.3	0.1	0.1	0.01	0.1	0.4
Tripleurospermum perforatum (Merat) M. Lainz	0.02	0.02	0.1	0.02	0.0	0.0	0.1	0.02

Veronica arvensis L.	0.04	0.01	0.5	0.02	0.01	0.001	1.6	0.1
Vicia angustifolia L.	0.01	0.004	0.2	0.1	0	0	0.3	0.2
Viola arvensis Murray	0.1	0.004	0.4	0.2	0.2	0.04	1.7	0.4
All annual weeds	17.9	6.1	30.0	14.8	23.1	10.8	45.6	31.1
Achillea millefolium L.	0.2	0.1	0.0	0.0	0.01	0.001	0.0	0.0
Artemisia vulgaris L.	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Cerastium arvense L.	0.001	0.01	0.0	0.0	0.0	0.0	0.1	0.01
Cirsium arvense (L.) Scop.	18.1	43.1	61.1	205.1	6.4	11.2	14.5	60.3
Elytrigia repens (L.) Nevski	3.5	2.8	8.2	10.8	2.1	1.4	10.0	16.1
Glechoma hederacea L.	0.4	0.1	0.0	0.0	0.4	0.1	0.0	0.0
Medicago lupulina L.	0.0	0.0	0.0	0.0	0.01	0.001	0.0	0.0
Mentha arvensis L.	1.0	0.2	0.7	0.2	0.2	0.02	0.6	0.3
Plantago major L.	0.04	0.1	0.6	0.2	0.01	0.1	1.1	0.4
Ranunculus repens L.	0.3	0.2	0.0	0.0	0.2	0.2	0.0	0.0
Rumex crispus L.	0.4	0.9	0.2	0.4	0.4	0.4	0.1	0.2
Sonchus arvensis L.	27.2	27.2	25.9	86.8	18.7	27.4	32.0	94.2
Stachys palustris L.	0.2	0.15	1.1	1.4	0.2	0.03	0.4	0.1
Trifolium spp. L.	0.1	0.1	0.0	0.0	0.4	0.1	1.3	0.1
Tussilago farfara L.	2.2	2.1	1.3	2.6	3.8	3.8	1.5	3.2
All perennial weeds	53.6	77.1	99.0	307.4	32.7	44.9	61.6	174.9
All weeds	71.5	83.2	129.0	322.2	55.8	55.7	107.2	205.9
LSD_{05} (weed number)	22.5 (for spring wheat crop)		71.1 (for buckwheat crop)					
LSD_{05} (weed air-dry biomass)	33.6 (for spring wheat crop)		161.3 (for buckwheat crop)					

Elytrigia repens, Cirsium arvense, Tussilago farfara and *Plantago major* density and biomass have a tendency to decrease in separate years of the trial. Consequently, two-layer ploughing has potential for perennial weed control in alternative – organic agriculture, although it has not been sufficiently explored and is still underrated. There are many unanswered questions pertaining to perennial weed control in organic agriculture. For a deeper understanding of perennial weed control possibilities in organic agriculture by non-chemical means the experiments should be continued to optimise agro-technics, an adequate system and quality of agricultural machinery.

CONCLUSIONS

The experimental field was infested by 41 weed species, of which 26 were annual and 15 were perennial. In the spring wheat crop 37 weed species were established: 22

annual and 15 perennial and in buckwheat crop there were 36 weed species: an increase of 26 annual weed species and a decrease of 26 perennial ones.

The perennial weeds *Elytrigia repens, Cirsium arvense, Sonchus arvensis, Tussilago farfara* and *Plantago major* dominated in the crop while the annual weeds, the most widespread of which were *Chenopodium album*, *Capsella bursa-pastoris* and *Stellaria media,* were in recessive position. Annual weeds were highly suppressed by the perennial ones. In the crop of spring wheat and buckwheat, perennial weed comprised 59%–71% and 57%–77% of total weed number, 81%–93% and 85%–95% of total weed air-dry mass in plots ploughed by two-layer and 'cultural' cylindrical ploughs, respectively.

Cirsium arvense comprised 56%–67% of total perennial weed air-dry mass in plots ploughed with 'cultural' cylindrical plough and decreased till 25%–34% in plots ploughed with the two-layer plough in crops of spring wheat and buckwheat, respectively. A decrease in *Cirsium arvense* air-dry mass by 3.4–3.9 times was recorded. *Elytrigia repens, Tussilago farfara* and *Plantago major* density and biomass had a tendency to decrease in separate years of the trial while *Sonchus arvensis* remained. It was confirmed that ploughing with a two-layer plough decreases crop weediness when compared with cylindrical one.

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