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Chemical weed control in winter wheat (*Triticum aestivum* L.) crop of early stages of development: I. Crop weediness

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Abstract

Field trials were carried out at Jonas Aliukonis farm in Prienai district Strielciai village during 2005-2006. Influence of 5 herbicides applied in autumn on crop of winter wheat was investigated. Winter wheat (*Triticum aestivum* L.) is sensitive to weed competition in early stages of growth and development. Conventionally herbicides are used in spring for weed control in winter cereals, therefore, perennial and winter annual weeds have favorable conditions to grow and compete with cereals when vegetation in spring is renewing. The work hypothesis is that application of herbicides in autumn will control weeds that survive during winter time and winter wheat will not be damaged and better conditions for crop competition in spring after renewing of vegetation will be created. Weediness of winter wheat crop did not have any essential differences before herbicide application in autumn. After herbicide spraying in autumn weediness of winter wheat crop decreased till 15.4-28.4% and the air-dry biomass decreased even till 56.8%. Weeds were most efficiently controlled with Monitor in autumn comparing with non-treated control and other herbicides applied. Crop weediness decreased by 18 weeds m^{-2} and 9.5 g m^{-2} of air-dry biomass, it covered 28.4% and 56.8%, respectively.

Key words: Weeds, weed control, herbicides, winter wheat, early stages of development.

Introduction

The field crops of cultured plants are plant associations or so-called agrophytocenoses, and the total biomass of a crop stand (crop and weed biomass) is more or less constant and the crop yield is inversely proportional to the weed biomass [1, 2]. Effectiveness of chemical weed control is determined by three main specifications: selection of an adequate herbicide, its optimal dose and duration of application. In the process of weed control it should be remembered that wet climate, cold spring weather and long autumn are the factors that help weeds growth and development. Another important factor is the ratio of weed biological groups. The prevailing weeds in Lithuania are short-lived dicotyledons that comprise 70-90% of all the weeds [3]. Germination of weeds is most intensive in the period from the middle of May until the second half of June [4, 5]. This is also the time when supervisory work of crop is being accomplished. When crop is harrowed and inter-beds are cultivated, a lot of weeds are eliminated, however, in some cases these measures are not sufficient [6]. The number and mass of weeds decreases considerably when winter wheat crop is cultivated three times. Depending on meteorological conditions, especially during dry years, one-time cultivation is also effective for destroying weeds just after renewal of winter wheat vegetation BBCH 22-24 [7]. Crop weediness is considerably reduced when soil is adequately cultivated, herbicides are applied and crop rotations are practiced [8, 9]. Intensive use of herbicides following the traditional crop growing technologies, however, does not entirely solve the problem of weediness.

Hypothesis and aim of the research: Herbicides are conventionally used in spring to destroy weeds in winter crop, however, this way conditions for survival and maturity of perennial and short-lived winter weeds, wintering and biannual weeds are formed. After vegetation renewal in spring the weeds can successfully compete with winter crop.

If herbicides to control crop weeds are applied in autumn, the weeds traditionally surviving winter will be destroyed and more favourable conditions for weed control in spring after renewal of winter wheat vegetation will be shaped.

Aim was to investigate the effect of herbicides in winter wheat crop at the beginning of vegetation, that is, in autumn.

Materials and Methods

The research was carried out in Prienai district, Asminta region, Strielciai village, Jonas Aliukonis farm in 2005 -2006. Winter wheat "ADA" was sown on 12 September, 2005. The sowing-machine SPU -6 (inter-beds 12.5 cm) was used. The field was fertilized in autumn (10 September, 2005) by amofos 100 kg ha^{-1} and potassium chloride 200 kg ha^{-1}. The amount of seeds comprised 240 kg ha^{-1} and the sowing depth was 4-5 cm. The investigated herbicides (according to the scheme of research) were applied at BBCH 14-15 (7 October 2005). The pre-crop was black fallow. For the first fertilization in spring (12 April, 2006) 250 kg ha^{-1} of ammonium nitrate was used and for the second fertilization (8 May, 2006) 200 kg ha^{-1} of ammonium nitrate was applied. A composite of herbicides Sekator 300 g ha^{-1} and MCPA 1 L ha^{-1} with a growth regulator

Cycocel 1.5 L $ha^{-1}$was used for background spraying at BBCH 22-23 (2 May, 2006). At the beginning of winter wheat stem elongation (25 May, 2006) the composite of insecticide Fastak 100 g ha^{-1}, fungicide Folikur 0.75 L ha^{-1} and complex fertilizer Wuxal 5 L ha^{-1} was sprayed.

The experiment was carried out in four replications. The total area of the plots comprised 38.4 m^2. To prepare for the experiment the plots were ploughed in autumn using semi-helical plough Overum 4 to the depth of 24 cm, cultivated using a cultivator with comb harrow KPŠ-15 to the depth of 10 cm and the surface of soil was levelled off with a roller PP-7.

Scheme of research:

1. Control not sprayed with herbicides in autumn.
2. Monitor 75% g (sulphosulphuron 750 g kg^{-1}), 26.7 g ha^{-1}.
3. Atribut 70% w.s.g. (propoxycarbazone-sodium 700 g kg^{-1}), 0.120 g ha^{-1}.
4. Mustang 458,75 g L^{-1} c.s. (florasulam + 2,4-D 2-ethylhexyl ester 6.25 + 452.5 g L^{-1}), 0.5 L ha^{-1}.
5. Logran 20% w.s.g. (triasulphuron 200 g kg^{-1}), 0.03 g ha^{-1}.
6. Husar 5% w.s.g. (iodosulphuron-methyl-sodium 50 g kg^{-1}), 0.200 g ha^{-1}.

Note: g granules; w.s.g. water-soluble granules; g L^{-1} c.s. grams in a litre of concentrated suspension.

Weediness of winter wheat crop was established applying the quantitative weighed method in autumn and spring during the tillering period before and after spraying taking samples of each treatment in all replications in the four plots using wire rim of 50 cm x 50 cm.

Soil samples for agrochemical analysis and the establishment of weed seeds, quantity of varietal composition and distribution in topsoil were taken from all treatments, all replications in 0-20 cm topsoil layer at the end of September in 2005. Soil agrochemical features were established in the Centre of Agrochemical Research, Lithuanian Agricultural Institute, using the computerised system of infrared rays PSCCO/ISI IMB - PC 4250.

Soil characteristics: Soil in the research plots comprised Gleyic Cambisols CMg. Topsoil layer was alkaline (pH 7.1), average in humus (2.17 %), rich in phosphorus (152 mg kg^{-1}) and average in potassium (146 mg kg^{-1}).

Meteorological conditions: Climate of the Lithuania territory forms in different radiation and circulation conditions. Differences in these conditions hardly cross the boundaries of microclimatic differences; therefore, according to B.P. Akisovas, the whole Lithuania belongs to western region of the Atlantic Ocean continental climatic area [10]. In 2005-2006 meteorological conditions were favourable for winter wheat crop establishment. Autumn of 2005 was warm and rainy, i.e. suitable for crop emergence and early growth. The beginning of winter delivered well balanced conditions for wintering, however, during January - March 2006 the temperatures were rather low with insufficient snow cover on the soil. April -June 2006 was cool with high variation of rainfall which principally did not exceed the long-term average. Significant increase of rainfall in August resulted in complicated conditions for winter wheat maturing and harvesting.

The trial data were evaluated using analysis of variance by 'Selekcija' [11].

Results and Discussion

Distribution of weed seeds in the topsoil layer: The seeds of *Chenopodium album* L. prevailed in the soil seed bank (100 g of air-dry soil in the layer of 0-20 cm). They comprised from 35.8 to 50 percent of the whole seed bank (Table 1). *Viola arvensis* Murray was another dominant weed in the soil seed bank. The greatest number of its seeds (3.75 units) was established in the third treatment (Atribut) and the least number of seeds (1 unit) was found in the first treatment (control) (Table 1). The third treatment contained the greatest number of weed seeds (Atribut was sprayed) where 13.4 units of weed seeds were established, that is, by 41.7 percent more compared to control treatment. The second treatment contained the least number of weed seeds (5 units) (Monitor was applied).

Weediness of winter wheat crop: Short-lived weeds such as *Centaurea cyanus* L., *Thlaspi arvense* L., *Raphanus raphanistrum* L. and *T. perforatum* prevailed in winter wheat crop whereas among

Table 1. Distribution of weed seeds in the 0-20 cm topsoil layer, units in 100 g of air-dry soil, 2005.

Weed	Control treatment (herbicides are not applied)	Herbicide				
		Monitor	Atribut	Mustang	Logran	Husar
	Units in 100 g of air-dry soil					
Chenopodium album L.	3	2	4.25	2.75	4	4.75
Myosotis arvensis (L) Hill	0	0.25	0.25	1	0.25	1.75
Rumex crispus L.	0.75	0.25	1	0.75	0.75	1.5
Viola arvensis Murray	1	1.25	3.75	2	2.5	2.75
Thlaspi arvense L.	0	0	0.25	0.5	0.25	0.25
Stellaria media (L.)Vill.	0.75	0.5	1.75	0	0.5	1.75
Fallopia convolvulus L.	0	0	0	0	0.5	0
Sinapis arvensis L.	0.25	1	0	0.25	0.25	0.25
Galeopsis tetrahit L.	0	0	0.25	0	0	0
Tripleurospermum perforatum (Merat) M. Lainz	0.50	0.5	0.75	0	0	0
Persicaria lapathifolia L.	0	0	0	0	0	0.25
Cirsium arvense (L.) Scop.	0	0	0.25	0	0	0
All weed seeds	6.25	5.75	12.5*	7.25	9	13.25*
LSD_{05}	4.34					

Note. * - essential differences at 95% level of probability, compared to control treatment.

perennial weeds only of *Sonchus arvensis* L. and *Plantago major* L. and a few plants of *Antennaria dioica* L. and *Poa trivialis* L. emerged in the crop. Short-lived weeds in the crop of winter wheat in autumn and after application of the said herbicides comprised 96-100% and 93-100%, respectively, whereas in spring before and after application of background herbicides they comprised 89-100% and 99-100%, respectively. This means that perennial weeds are better adapted to wintering than the short-lived ones because the increase of air-dry biomass up to 11% was established in spring before the application of weed control measures (Table 2).

In the fields of winter wheat crop sprayed in autumn before the spring spraying considerable differences in weed air-dry biomass have not been determined, however, weed air-dry biomass in spring had a tendency to decrease compared to the fields not sprayed with herbicides in autumn. After background application of herbicides Sekator 300 g ha^{-1} and the composite of MCPA 1 L ha^{-1} and growth regulator Cycocel 1.5 L ha^{-1} in spring and Monitor, Logran and Husar in autumn reliable reduction in the number of weeds in winter wheat crop by 52, 33.8, 45.9 and 37.8%, respectively, compared to the control treatment was established. In the fields where Atribut was applied in autumn the number of weeds had a tendency to decrease. A square metre had 16 weeds less compared to the control treatment without herbicide application (Table 2).

Assessing the effectiveness of diverse herbicides it was established that the number of weeds after spraying in autumn decreased by 32.4-91.7 percent compared to the non-sprayed control. Assessing winter wheat crop in spring, autumn application of herbicides resulted in lessened crop weediness after its wintering even before spring spraying. The number of weeds

Table 2. Varietal composition of weeds in winter wheat crop, number [units per m^{-2}] and air-dry mass [g m^{-2}] before and after herbicide application in autumn of 2005 and spring of 2006.

Weeds	Average of weed number and air-dry mass											
	Control		Monitor		Atribut		Mustang		Logran		Husar	
	units m^{-2}	g m^{-2}	units m^{-2}	g m^{-2}	units m^{-2}	g m^{-2}	units m^{-2}	g m^{-2}	units m^{-2}	g m^{-2}	units m^{-2}	g m^{-2}
Before autumn spraying (2005)												
Stellaria media (L.)Vill	5.00	0.07	7.5	0.15	6.5	0.16	3.25	0.08	5.5	0.52	3.25	0.03
Capsella bursa-pastoris (L.) Medik.	8.75	0.15	7.75	1.93	4.25	0.08	6.25	0.09	4.75	5.64	3.25	0.06
Thlaspi arvense L.	8.75	0.21	9.00	0.87	12.00	1.23	9.5	0.15	6.75	8.66	9.25	0.29
Raphanus raphanistrum L.	9.75	2.99	6.00	8.25	8.00	1.72	3.25	1.61	7.75	1.97	9.00	5.57
Tripleurospermum perforatum (Merat) M.Lainz	4.00	0.02	3.00	0.52	4.25	0.05	1.75	0.01	2.5	0.63	3.25	0.04
Centaurea cyanus L.	23.25	1.03	16.5	2.21	25.25	10.99	35.25	1.67	19.5	2.16	31.5	1.14
Galium aparine L.	1.25	0.02	2.25	0.03	2.00	0.02	3.25	0.06	4.00	0.05	5.25	0.09
*Other annual weeds	1.00	1.70	7.25	1.87	0.75	0.03	3.50	0.16	5.00	1.38	2.00	0.05
All annual weeds	61.75	6.19	59.25	15.83	63.00	14.28	66.00	3.83	55.75	21.01	66.75	1.70
**All perennial weeds	0.25	0.05	0.50	0.41	0.25	0.17	0.25	0.00	0.00	0.00	0.25	0.06
All weeds	62.00	6.24	59.75	16.24	63.25	14.45	66.25	3.83	55.75	21.01	67.00	1.76
After autumn spraying (2005)												
Stellaria media (L.)Vill	11.75	0.24	3.75	1.17	6.00	0.68	1.50	0.39	7.5	2.33	1.50	0.05
Capsella bursa-pastoris (L.) Medik.	6.00	0.17	4.25	1.67	4.00	0.12	4.00	0.10	4.75	1.53	3.00	0.08
Thlaspi arvense L.	7.25	0.33	6.00	0.47	2.75	0.19	5.00	0.66	5.25	0.75	7.00	0.60
Raphanus raphanistrum L.	4.50	2.10	6.25	1.35	5.25	2.83	3.50	1.37	2.50	1.84	3.75	0.99
Tripleurospermum perforatum (Merat) M.Lainz	4.00	0.11	1.75	0.14	1.25	0.04	1.00	0.01	3.00	0.09	2.25	0.06
Centaurea cyanus L.	22.00	3.12	15.5	1.72	19.50	2.03	24.50	3.10	18.25	3.17	30.25	2.99
Galium aparine L.	4.00	0.10	3.75	0.08	2.75	0.00	5.50	0.05	3.75	0.12	7.00	0.13
Raphanus sativus L.	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.37	0.00	0.00	0.00	0.00
*Other annual weeds	3.25	0.08	2.75	0.55	7.00	0.21	1.5	0.06	3.25	0.21	2.25	0.06
All annual weeds	62.75	6.25	44.00	7.15	48.50	6.10	46.75	6.11	48.25	10.04	57.00	4.96
**All perennial weeds	0.25	0.43	0.00	0.00	0.50	0.00	0.25	0.63	0.00	0.00	0.75	0.10
All weeds	63.00	6.68	44.00	7.15	49.00	6.10	47.00	6.74	48.25	10.04	57.75	5.06
Before spring spraying (2006)												
Stellaria media L.	5.5	0.24	3.23	0.97	4.00	0.68	0.5	0.31	5.1	2.00	0.6	0.03
Capsella bursa-pastoris (L) Medik.	8.00	0.23	4.25	1.8	4.8	0.15	4.00	0.10	3.50	1.47	3.20	0.09
Thlaspi arvense L.	6.31	0.39	5.60	0.47	2.23	0.18	4.4	0.57	5.10	0.75	7.20	0.63
Raphanus raphanistrum L.	3.87	1.80	5.37	1.16	4.51	2.43	3.01	1.18	2.15	1.58	3.22	0.85
Tripleurospermum perforatum (Merat) M.Lainz.	4.30	0.23	1.63	0.12	1.76	0.05	1.50	0.03	3.60	0.12	1.68	0.04
Centaurea cyanus L.	20.9	3.00	14.72	1.63	18.52	1.93	23.27	2.94	17.33	3.01	28.73	2.84
Galium aparine L.	4.8	0.23	3.56	0.07	2.58	0.01	5.33	0.05	3.52	0.14	6.72	0.11
Raphanus sativus L.	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.38	0.00	0.00	0.00	0.00
*Other annual weeds	4.3	0.46	1.89	0.17	5.18	0.16	1.4	0.05	2.09	0.1	2.31	0.19
All annual weeds	57.98	6.58	38.62	6.39	43.58	5.59	43.66	5.61	42.39	9.17	53.66	4.78
**All perennial weeds	0.00	0.00	1.00	0.53	0.00	0.00	0.10	0.64	0.00	0.00	0.00	0.00
All weeds	57.988	6.58	39.62	6.92	43.58	5.59	43.76	6.25	42.39	9.17	53.66	4.78
After spring spraying (2006)												
Stellaria media (L.)Vill	3.4	0.24	2.23	0.67	2.7	0.45	0.25	0.14	3.39	1.00	0.3	0.01
Capsella bursa-pastoris (L) Medik.	6.9	0.31	1.29	0.38	2.40	0.40	0.30	0.11	2.55	1.30	0.21	0.03
Thlaspi arvense L.	7.41	0.41	7.62	1.21	3.23	1.18	2.34	0.28	3.10	0.34	3.44	0.33
Raphanus raphanistrum L.	6.87	2.80	2.14	1.00	5.41	2.92	2.40	0.94	1.72	1.26	2.57	0.68
Tripleurospermum perforatum (Merat) M.Lainz.	7.98	1.47	1.19	0.05	2.31	0.08	1.00	0.02	2.73	0.05	1.00	0.02
Centaurea cyanus L.	1.55	0.01	1.24	0.03	1.98	0.03	2.54	0.26	1.73	0.45	0.35	0.02
Galium aparine L.	2.8	0.03	3.16	0.04	2.18	0.01	4.33	0.05	3.12	0.14	5.72	0.11
Raphanus sativus L.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Other annual weeds	0	0	0.45	0.04	1.46	0.09	1.01	0.05	0.27	0.02	0.41	0.06
All annual weeds	36.92	5.27	19.32	3.42	21.67	5.16	14.17	1.85	18.64	4.59	14	1.26
**All perennial weeds	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All weeds	36.93	5.27	19.32	3.42	21.67	5.16	14.17	1.85	18.64	4.59	14.00	1.26

Note: * Other annual weeds - *Chenopodium album* L., *Erysimum cheiranthoides* L., *Sinapis arvensis* L., *Myosotis arvensis* (L.) Hill, *Veronica arvensis* L., *Cerastium arvense* L., *Fumaria officinalis* L., *Viola arvensis* Murray, *Galeopsis tetrahit* L., *Polygonum aviculare* L. ** All perennial weeds - *Plantago major* L., *Sonchus arvensis* L., *Antennaria dioica* L., *Poa trivialis* L.

decreased by 70.7-92.4 compared to the control with no autumn herbicide application (Table 2).

Conclusions

In the soil seed bank the seeds of *C. album* and *V. arvensis* prevailed comprising up to 50% and 37.5%, respectively, of the seed bank, whereas *C. cyanus*, *T. arvense*, *R. raphanistrum* and *T. perforatum* dominated in the crop.

Before autumn application of herbicides there were no considerable differences in weediness of winter wheat but after herbicide spraying the number of weeds decreased by 15.4-28.4% and their air-dry biomass lessened even by up to 56.8%.

Monitor was most effective in destroying weeds in winter wheat crop in autumn compared to the control with no autumn herbicide application and other herbicides used. Crop weediness decreased by 18 weeds m^{-2} and by 9.5 g m^{-2} of air-dry mass; the reduction comprised 28.4% and 56.8%, respectively.

Assessing the effectiveness of different herbicides it was established that after autumn spraying the number of weeds decreased from 32.4% to 91.7% compared to unsprayed control. Assessing winter wheat crop in spring, autumn herbicide application resulted in reduced weediness after crop wintering still before spring spraying.

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