NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 31, 2014
Print ISSN 1222-4227; Online ISSN 2067-5720

THE EFFECT OF CHLORSULFURON ON WEEDS IN WINTER WHEAT

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ABSTRACT

The objective of the study was to determine the effect of chlorsulfuron on weeds in winter wheat grown in monoculture. A field experiment was conducted in east-central Poland in the years 2004-2009. The soil of the experiment was grey brown podzolic soil. Chlorsulfuron was applied as Glean 75 DF at rates ranging from 15 and 60 g ha^{-1}.

We found 34 weeds in the experimental plots, including 25 annuals and 9 perennials. Increasing chlorsulfuron rates produced the following effects: the floristic richness of the community and weed infestation were reduced, but the share of perennial and monocot weed species increased. The effect of monoculture wheat was similar, though the impact of monoculture on weed community floristic impoverishment was less pronounced.

Two dominant species, that is *Elymus repens* and *Apera spica-venti*, occurred during the study period. Increased numbers of *Apera spica-venti* were recorded in all the chlorsulfuron-controlled plots, even if the chemical was applied at the highest rates. This may be indicative of the development of a chlorsulfuron-resistant weed population.

Key words: herbicides, monocot weed compensation, resistance to herbicides, weed compensation.

INTRODUCTION

Winter wheat grown in monoculture produces markedly lower yields. This is partially due to an increased weed infestation (Adamiak et al., 2011) and unfavourable changes in its structure. Chemicals applied to control weeds impoverish segetal communities (Andreasen et al., 1996; Meyer et al., 2008).

Moreover, compensation of species resistant to the most popular herbicides and development of resistance to herbicides are frequently observed (Whitehead and Switzer, 1963, Balgheim et al., 2007, www.weedscience.com). Weed communities undergo compensation by monocot weeds and perennial species. The aforementioned processes are believed to be on the increase when herbicides are not rotated and weed control mainly includes an application of herbicides.

There are many studies which confirm that it is advisable to apply lower herbicide rates due to ecological and economic reasons (Walker et al., 2002; Urban and Grządka, 2012). It has not been settled yet whether or not this technology contributes to the development of weed resistance to herbicides and compensation of resistant species.

The objective of this study was to determine how weeds develop in monoculture winter wheat, when they are controlled using chlorsulfuron applied at different rates.

MATERIAL AND METHODS

The field experiment was conducted over the years 2004-2009 in east-central Poland. The soil was grey brown podzolic soil classified as the very good rye complex of soil quality. The trial layout was a randomised block design with four replicates. Experimental plot size was 2 x 8 m. Winter wheat cv Korweta was grown in monoculture, the seeding rate was 250 kg/ha, and the mineral fertilisation was as follows: 80 kg N,

Received 29 November 2013; accepted 13 February 2014. First online: 25 June 2014. DII 2067-5720 RAR 2014-454

70 kg P_2O_5, and 90 kg K_2O per 1 ha. The experiment aimed at determining the effect of chlorsulfuron rate on the occurrence of weeds in monoculture wheat in successive study years. The chlorsulfuron rates were as follows:

1. control – no chemical;
2. Glean 75 DF (chlorsulfuron) applied at a rate of 15 $g \cdot ha^{-1}$ in autumn;
3. Glean 75 DF applied at a rate of 25 $g \cdot ha^{-1}$ in autumn;
4. two applications of Glean 75 DF: at a rate of 25 $g \cdot ha^{-1}$ in autumn and 15 $g \cdot ha^{-1}$ in spring (in total 40 $g \cdot ha^{-1}$);
5. three applications of Glean 75 DF at a rate of 20 $g \cdot ha^{-1}$ (2 sprayings in autumn, 1 in spring, in total 60 $g.ha^{-1}$).

Weed infestation was examined by the quadrate method – all the weeds were calculated in a 1 m^2 area prior to wheat harvest. The results of the observations used to analyse weed infestation included:

a) the effect of chlorsulfuron rate and lack of crop rotation on the number of all weed species per 1 m^2;

b) the structure of weed communities established in response to the influence of different herbicide rates as well as cultivation in monoculture, in particular:

- floristic richness of a community;
- the share of perennial species;
- relationships between monocot and dicot taxa;
- dominant species in a community.

The results obtained were subjected to the two-way analysis of variance. Differences between means for years and herbicide rates and their interaction were checked using the Tukey's test at a significance level of 0.05 (Trętowski and Wójcik, 1992).

RESULTS AND DISCUSSION

A total of 34 weed species were identified in the experimental plots. Short-lived species predominated (25) and they included: *Centaurea cyanus*, *Matricaria maritima* ssp. *inodora*, *Apera spica-venti*, *Sonchus asper*, *Gnaphalium uliginosum*, *Echinochloa crus-galli*, *Fallopia convolvulus*, *Polygonum aviculare*, *Viola arvensis*, *Juncus bufonius*, *Galeopsis tetrahit*, *Setaria pumila*, *Setaria viridis*, *Plantago intermedia*, *Conyza canadensis*, *Galinsoga parviflora*, *Bromus secalinus*, *Stellaria media*, *Chenopodium album*, *Poa annua*, *Veronica arvensis*, *Anchusa arvensis*, *Vicia tetrasperma*, *Lycopsis arvensis*, *Senecio vulgaris*. Perennials included 9 species only: *Rumex crispus*, *Plantago maior*, *Elymus repens*, *Artemisia vulgaris*, *Taraxacum officinale*, *Cirsium arvense*, *Equisetum arvense*, *Trifolium repens* and *Trifolium pratense*.

Floristic richness of weed communities depended on herbicide rates. The poorest communities were found in plots where weeds had been controlled using higher chlorsulfuron rates. Significantly more species were observed when weeds were controlled with the average rate. The greatest numbers of taxa were identified in the control plots, as well as in the plots where the lowest herbicide rate had been applied. Similar relationships were observed over the whole study period excluding 2009 when comparable numbers of weeds were observed regardless of the herbicide rate applied.

Weed species diversity was similar in successive years of monoculture except for the year 2005 when the species number was significantly higher than in the remaining years (Table 1). An adverse effect of herbicides on weed biodiversity has been confirmed in the study by Adamiak et al. (2011).

Declining weed community biodiversity is an unquestionably negative process. A weed community which is made up of several species is very often more harmful than a community consisting of more than 10 components (Anyszka and Kohut, 2011). When a chlorsulfuron rate was increased by 45 $g \cdot ha^{-1}$, weed number significantly dropped from 85.0 to 55.4 $plant \cdot m^{-2}$. Lower and standard herbicide rates in the first study year reduced weed numbers (but insignificantly), which agrees with findings reported by other authors (Haliniarz and Kapeluszny, 2010; Urban and Grządka, 2012). Monoculture which lasted more than three years contributed to significantly higher weed infestation levels (Table 1).

Table 1. Weed infestation in winter wheat, depending on chlorsulfuron rate and monoculture year

Study year	Chlorsulfuron rate, g·ha^{-1}					
	0	15	25	40	60	Mean
	Species number per community					
2004	6.5 b	5.5 ab	3.3 a	4.5 ab	3.8 ab	4.7 A
2005	7.8 a	10.3 b	7.5 a	4.8 a	5.0 a	7.05 B
2006	7.3 c	5.5 bc	3.8 ab	3.0 ab	1.8 a	4.25 A
2007	5.5 ab	8.8 c	7.3 bc	3.3 a	2.8 a	5.5 A
2008	7.3 b	5.0 ab	6.0 ab	4.0 a	3.3 a	5.1 A
2009	4.5 a	4.0 a	3.0 a	3.3 a	3.0 a	3.55 A
Mean	6.5 c	6.5c	5.1 b	3.8a	3.3 a	
	Weeds in total, plants m^{-2}					
2004	62.5 a	36.8 a	44.0 a	43.0 a	77.0 a	52.65 AB
2005	89.0 ab	116.5 b	62.0 ab	33.0 a	40.0 a	68.1 B
2006	48.0 a	27.0 a	25.0 a	15.0 a	12.5 a	25.5 A
2007	47.5 ab	86.5 ab	109.0 b	32.5 a	34.0 a	61.9 B
2008	69.5 a	69.5 a	79.0 a	69.5 a	68.0 a	71.1 B
2009	111.0 ab	174.0 b	129.0 ab	167.5 ab	101.0 a	136.5 C
Mean	71.3 ab	85.0 b	74.7 ab	60.1 ab	55.4 a	

Means in the same row followed by the same small letters do not differ significantly at P≤0.05.
Means in the last column followed by capital letters, for species number or number of weeds separately do not differ significantly at P≤0.05.

The experimental factors affected the structure of weed communities which underwent marked transformations. A rapid increase in the share of perennial weeds was observed, from 13.1% in the first study year to 77.3% in year six. A similar process occurred when herbicide rates were increased, from 24.9% (control) to 52.0-54.1% (higher rates) (Table 2).

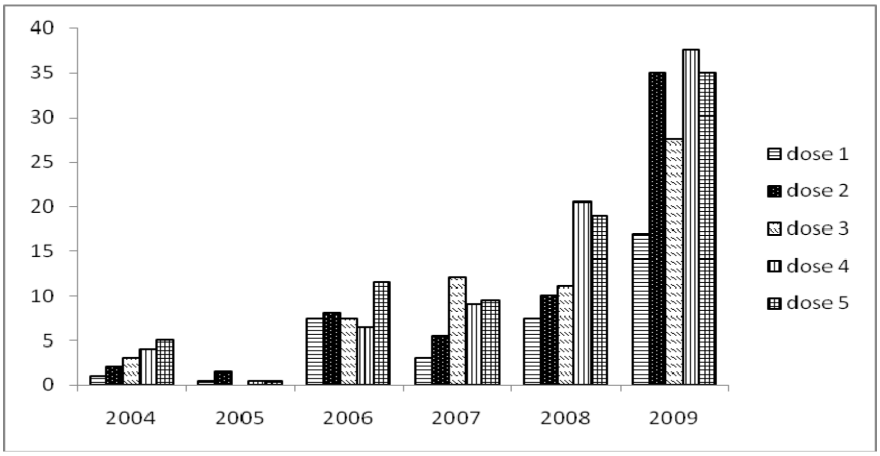
Table 2. Infestation with perennial and monocot weeds in winter wheat, depending on chlorsulfuron rate and monoculture year

Study year	Chlorsulfuron rate, g·ha^{-1}					
	0	15	25	40	60	Mean
	% share of perennial weeds					
2004	6.2 a	12.4 a	20.0 a	17.5 a	9.4 a	13.1 A
2005	12.1 a	13.2 a	14.6 a	39.1 a	39.0 a	23.6 AB
2006	20.8 a	25.3 a	56.0 ab	56.6 ab	72.0 b	46.1 CD
2007	18.9 a	15.1 a	9.9 a	65.2 b	59.1 b	33.6 BC
2008	41.3 a	65.8 a	49.6 a	60.3 a	52.9 a	54.0 D
2009	50.3 a	82.2 b	88.6 b	85.9 b	79.5 b	77.3 E
Mean	24.9 a	35.7 ab	39.8 bc	54.1 d	52.0 cd	
	% share of monocot weeds					
2004	34.5 a	13.1 a	14.7 a	12.3 a	42.4 a	23.4 A
2005	41.9 a	15.7 a	27.4 a	40.1 a	34.1 a	31.8 A
2006	22.0 a	47.6 ab	74.1 bc	93.1 c	100.0 c	67.4 B
2007	49.1 ab	25.8 a	15.6 a	71.6 b	71.3 b	46.7 A
2008	52.9 ab	57.6 ab	37.1 a	79.0 bc	98.5 c	65.0 B
2009	81.0 a	95.0 a	99.0 a	99.1 a	100.0 a	94.8 C
Mean	46.9 a	42.5 a	44.7 a	65.9 b	74.4 b	

Means in the same row followed by the same small letters do not differ significantly at P≤0.05.
Means in the last column followed by capital letters, for each of perennial or monocot weeds shares separately, do not differ significantly at P≤0.05.

The higher the herbicide rate applied, the higher the share of grassy weeds was observed, although the differences were not always significant. The highest share of these weeds was observed when the herbicide rates had been doubled and tripled. This is a definitely negative phenomenon. Grassy weeds occurring in cereals are highly competitive towards the crop plants, as they have got a similar morphology and needs (Wellmann and Feucht, 2002). As a result, marked yield losses may be observed, even when grassy weeds are not very numerous (Mennan et al., 2002).

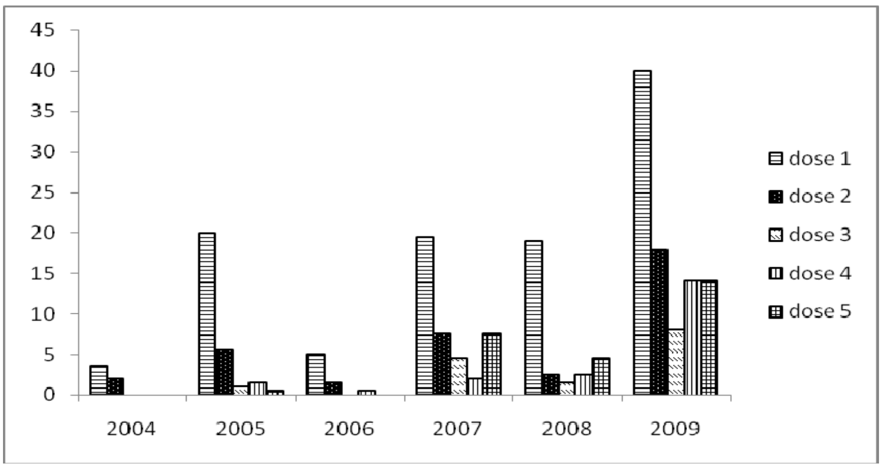
Two dominant species, *Elymus repens* and *Apera spica-venti*, were observed in the weed communities during the whole study period. *Elymus repens* compensation occurred in successive study years. After four and five years of monoculture, the plant number of this species increased from 0.6 to, respectively, 30.5 and 106 plants. Chemical control including an application of 15, 25 and 40 g $\cdot ha^{-1}$ significantly increased the size of the population compared with non-sprayed control. The tripled chlorsulfuron rate did not statistically influence the population of this taxon (Figure 1).



Legend: 1- control; 2- Glean 75 DF at the rate of 15 g ha^{-1}; 3- Glean 75 DF at the rate of 25 g ha^{-1}; 4- Glean 75 DF at the rate of 40 g ha^{-1}; 5- Glean 75 DF at the rate of 60 g ha^{-1}.

Figure 1. Elymus repens numbers in winter wheat, depending on chlorsulfuron rate and monoculture duration

The size of *Apera spica-venti* population fluctuated in successive study years. It increased in the fourth and sixth year of monoculture. Spraying with chlorsulfuron significantly reduced *Apera spica-venti* number compared with the control (Figure 2).



Legend: 1-control; 2-Glean 75 DF at the rate of 15 g ha^{-1}; 3- Glean 75 DF at the rate of 25 g ha^{-1}; 4- Glean 75 DF at the rate of 40 g ha^{-1}; 5- Glean 75 DF at the rate of 60 g ha^{-1}.

Figure 2. Apera spica-venti numbers in winter wheat depending on chlorsulfuron rate and monoculture year

It should be stressed that the taxon described established in all the herbicide-treated plots, regardless of chlorsulfuron rate, which may indicate that an herbicide-resistant population developed.

In addition to the aforementioned two taxa, four more species, that is *Viola arvensis*, *Gnaphalium uliginosum*, *Echinochloa crus-galli*, and *Cirsium arvense*, were quite frequent in the plots where winter wheat was cultivated. The remaining species were rare and did not affect the weed infestation level.

CONCLUSIONS

The study results have demonstrated that chlorsulfuron applied in winter wheat reduces weed infestation. Moreover, it substantially affects the species composition of weed communities. The result of this was species impoverishment of communities and the domination of perennials and monocotyledons.

Long-term application of chlorsulfuron to control weeds in continuous winter wheat may lead to the development of a chlorsulfuron-resistant *Apera spica-venti* population.

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