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Possibilities of weed control in spring cereals by herbicides applied at reduced rates

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Abstract. In the European countries leading in agricultural production like Great Britain, France, Germany and the Scandinavian countries, in the last several years, the tendency to use pesticides more rationally is observed. The tendency to reduce the use of pesticides is connected with the policy of the governments of the European Union countries.

In the years 2003–2006 the evaluation of herbicides' efficacy used at different rates for weed control in spring wheat and spring barley was tested. Each of tested herbicides was used at four rates – full recommended (100%) and at three lowered (75%; 50% and 25%).

The best results of weeds control in spring cereals gave tribenuron methyl plus an adjuvant which excellent reduced fresh mass of weeds even it was used at 25% of recommended rate. The same effect was observed after application half of recommended rate mixtures 2,4-D + florasulam, amidosulfuron+iodosulfuron, amidosulfuron+metribusin and 2,4-D + fluroxypyr. The similar results were occurred after application of MCPA + fluroxypyr at 75% recommended rate.

Application of herbicides at rates reduced by 25% to 75% to recommended rate had not significant impact on grain yield of spring barely and spring wheat.

key words: cereals, herbicides, reduced rates, weed control

INTRODUCTION

The positive impact of effective reduction of weed infestation is well recognized. Therefore the major objective of plant protection against weeds is the regulation of weeding to the level not endangering the crop and weakening the condition of the weeds. All aspects of this problem are strictly connected with the change of viewing the problem of human interference with the environment of segetal weeds occurring in a field of cultivated plant. The regulation of weeding becomes the superior objective of a herbicide treatment, meaning weakening the competition ability of weeds and limiting their amount to the level not endangering the cultivated plant.

The effective application of herbicides at reduced rates depends on some basic factors (Domaradzki, Rola, 2000), such as: sensitivity of the weed to used herbicide, the growth stage of the weed, the composition and number of weeds, the condition of crop and the weather conditions. The skilful connection of the information concerning the influence of those factors with the knowledge about the effects of the use of the reduced rates may ensure obtaining good effectiveness of weed control and high yielding.

For the last several years in many countries, the tendency to use pesticides more rationally has been observed. The tendency to reduce the use of pesticides is connected with the policy of the governments of the European Union countries. It is the result of the concern about the hazard to the environment and the reduction of the acceptable levels of residues of biologically active substances in plant products, which may have influence on the improvement of their quality (Gauvrit, 1991; Proven et al., 1991; Schwarz, 2004; Thonke, 1991; Whiting et al., 1991). Similarly as other EU members countries, Poland attempts to optimise herbicide use.

The aim of the research conducted in the Department of Weed Sciences and Soil Tillage Systems in Wrocław, Poland, was the assessment of effectiveness of reduced rates of herbicides and their influence on grain yield of spring wheat and spring barley.

MATERIALS AND METHODS

In the years 2003–2006 16 field experiments were conducted (10 in spring wheat and 6 in spring barley). Each experiment was a randomized blocks design and each treatment was replicated three times on fields of 20 m^2. All

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Table 1: Description of herbicides used in the study.

Herbicide trade name	Active ingredient (a.i.)	Content of a.i.	Herbicide rates per ha			
			full rate (100%)	reduced		
				75%	50%	25%
Chwastox Mix 292 EW	MCPA + fluroxypyr	250 g l^{-1} + 42 g l^{-1}	2 l	1.5 l	1 l	0.5 l
Granstar 75 WG + adjuvant	tribenuron methyl + adjuvant	75%	20 g	15 g	10 g	5 g
Lancet 530 EW	2,4-D + fluroxypyr	450 g l^{-1} + 80 g l^{-1}	1 l	0.75 l	0.5 l	0.25 l
Mustang 306 SE	2,4-D + florasulam	300 g l^{-1} + 6.25 g l^{-1}	0.6 l	0.45 l	0.3 l	0.15 l
Segal 65 WG	metribuzin + amidosulfuron	50% + 15%	120 g	90 g	60 g	30 g
Sekator 6,25 WG	amidosulfuron + iodosulfuron	5% + 1.25%	300 g	225 g	150 g	75 g

experiments were situated in arable fields of Lower Silesia region (South-West part of Poland). The description of tested herbicides is presented in Table 1.

Each of the tested herbicides was examined at the maximum recommended rate (100% of full rate) and at three reduced rates (75%, 50% and 25% of full rate). Herbicides were applied with a knapsack sprayer "Gloria", using 0.25 MPa air pressure and 250 l ha^{-1} spray volume. The application was performed in spring at the 3–4-leaf growth stage up to the beginning of tillering (BBCH=13-22) and at the 2–6-leaf stage of the weeds (BBCH=12-16). Evaluation of the weeds' fresh weight was done 5–6 weeks after application. The aboveground parts of weeds were cut (separately for each species) and weighed. Weeds from 3 random chosen places of each plot (3 × 0,25 m^2) were collected. Calculation of herbicides efficacy was performed on the basis of the fresh weight reduction in comparision to the untreated plots. Based on these calculations weeds were divided into four groups: sensitive (>85% of fresh weight reduction), medium sensitive (70–85%), medium resistant (60–69%) and resistant (<60%).

The trials were harvested with a field mini-combine "Nurserymaster Elite Z 035" at the full ripeness.

Experimental data were subjected to analysis of variance and least significant difference values were calculated at the 5% probability level LSD (0.05). Statistical analyses were performed using the AWAR 2.0 package.

RESULTS

Weed control efficacy

The tested herbicides showed different weed control levels in reference to investigated weed species and rates (Fig. 1). The best weed control results gave tribenuron methyl applied with an adjuvant. This herbicide controlled weeds in the range from 86% (at 25% of full rate) to

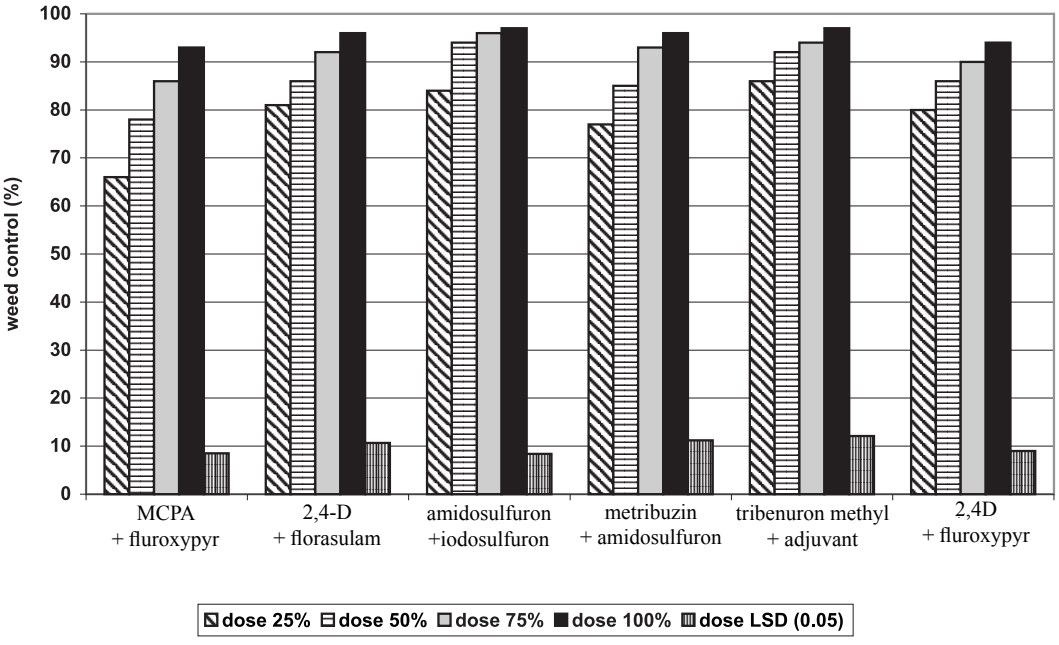

Fig. 1. Average weed control by different rates of investigated herbicides (on the base of 16 field trials).

Table 2. Weed control efficacy of MCPA + fluroxypyr, 2,4-D + florasulam and amidosulfuron + iodosulfuron applied at recommended and reduced rates.

Weed species	MCPA + fluroxypyr				2,4-D + florasulam				amidosulfuron + iodosulfuron			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Anthemis arvensis												
Brassica napus												
Chenopodium album												
Galium aparine												
Melandrium album												
Myosotis arvensis												
Polygonum convolvulus												
Polygonum lapathifolium												
Polygonum persicaria												
Stellaria media												
Thlaspi arvense												
Veronica persica												
Vicia cracca												
Viola arvensis												

Susceptibility of weeds:

susceptible (>85% of weed control)
medium susceptible (70–85%)
medium resistant (60–69%)
resistant (<60%)

Table 3. Weed control efficacy of metribuzin + amidosulfuron, tribenuron methyl with adjuvant and 2,4-D + fluroxypyr applied at recommended and reduced rates.

Weed species	metribuzin + amidosulfuron				tribenuron methyl + adjuvant				2,4-D + fluroxypyr			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Anthemis arvensis												
Brassica napus												
Chenopodium album												
Galium aparine												
Melandrium album												
Myosotis arvensis												
Polygonum convolvulus												
Polygonum lapathifolium												
Polygonum persicaria												
Stellaria media												
Thlaspi arvense												
Veronica persica												
Vicia cracca												
Viola arvensis												

Explanations – see Table 2.

97% (when was used at the full rate). Similar effects were observed after application of the mixture of amidosulfuron plus iodosulfuron (fresh weight of weeds decreased correspondingly from 84 to 97%). The herbicides – 2,4-D + florasulam; 2,4-D + fluroxypyr and metribuzin + amidosulfuron – applied at rates from recommended to reduced by 50% decreased fresh weight of all weeds by 85–96%. Twenty-five percent of full rate of this herbicides was less effective (77–81% of fresh weight reduction). The mixture of MCPA + fluroxypyr had the expected efficacy (>85%) only when applied at the full recommended rate or at a rate reduced by 25%. The remaining reduced rates of those mixtures led to noticeably lower efficacy.

Sensitivity of weeds to different rates of herbicides

Anthemis arvensis was very sensitive to all investigated herbicides at all tested rates (Tables 2, 3).

The similar situation was observed in the case of the voluntary *Brassica napus*. This weed also was very well controlled by all tested herbicides irrespective of applied rate (Tables 2, 3).

Chenopodium album was effectively eliminated by all tested rates of MCPA + fluroxypyr, 2,4-D + fluroxypyr and tribenuron-methyl with adjuvant. The same level of effectiveness was ensured by the mixtures 2,4-D + florasulam applied at full rate and reduced by 25–50%, and amidosulfuron + iodosulfuron at full rate and reduced by 25% (Tables 2, 3).

Galium aparine was characterised by certain variation in the susceptibility to investigated herbicides over the rates applied. The best effect of *G. aparine* control was observed after the application of the mixtures metribuzin + amidosulfuron and 2,4-D + fluroxypyr, irrespective of the examined rates. The similar effects after the application of the rates full and reduced by 25% and 50% of the mixtures 2,4-D + florasulam and amidosulfuron + iodosulfuron and also of the full recommended rate of tribenuron-methyl with the adjuvant were observed. The mixture MCPA + fluroxypyr was characterized by the insufficient activity of even the full rate (Tables 2, 3).

Melandrium album was very sensitive to all rates of amidosulfuron + iodosulfuron, tribenuron-methyl with the adjuvant and 50% of full rate metribuzin + amidosulfuron, 75%

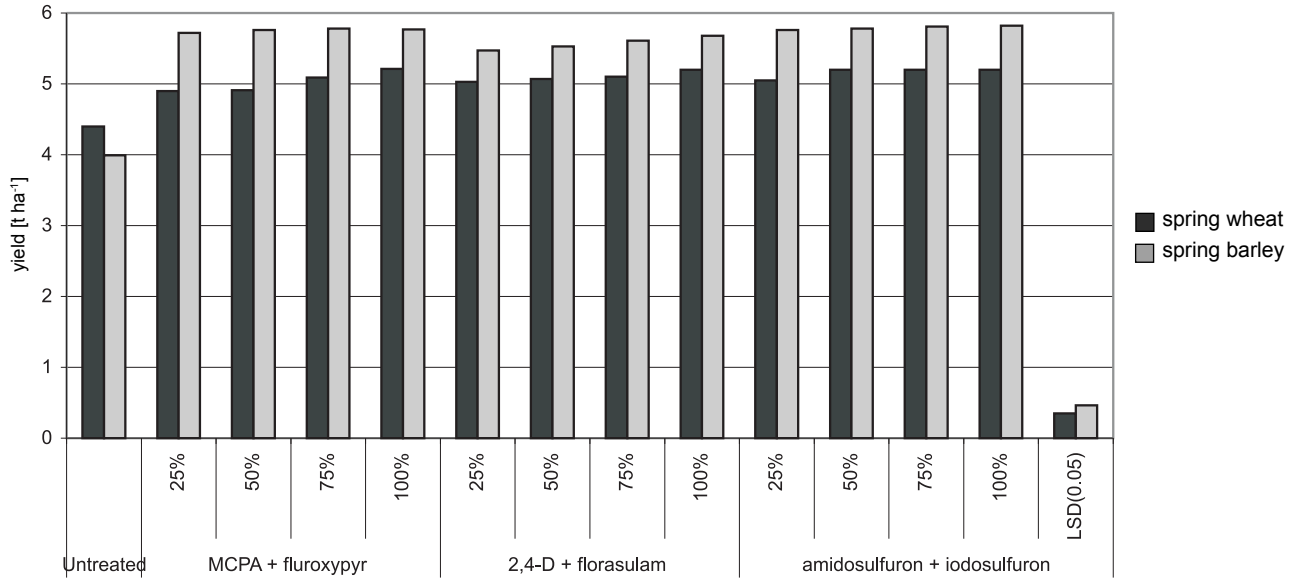

Fig. 2. Grain yield of spring wheat and spring barley treated by different rates of MCPA + fluroxypyr, 2,4-D + florasulam and amidosulfuron + iodosulfuron.

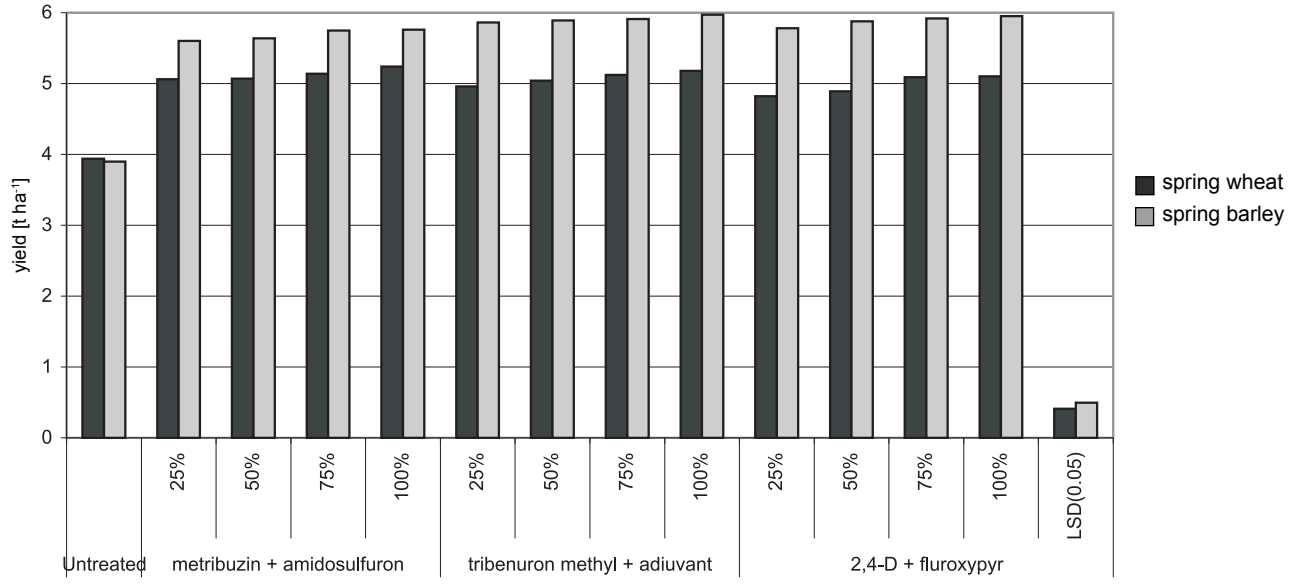

Fig. 3. Grain yield of spring wheat and spring barley treated by the different rates of metribuzin + amidosulfuron, tribenuron methyl with adjuvant and 2,4-D + fluroxypyr.

of full rate MCPA + fluroxypyr and full recommended rate of 2,4-D + fluroxypyr and 2,4-D + florasulam (Tables 2, 3).

Myosotis arvensis was efficiently controlled by 25% of full rate of MCPA + fluroxypyr, 2,4-D + florasulam, amidosulfuron + iodosulfuron, 50% rate of metribuzin + amidosulfuron, 75% of full rate of tribenuron-methyl with adjuvant and full rate of 2,4-D + fluroxypyr (Tables 2, 3).

The *Polygonum* species were characterised by certain diversification of the susceptibility in reference to investigated herbicides and their rates (Tables 2, 3). The most sensitive was *Polygonum persicaria.* It was very well controlled by all investigated herbicides applied at 25% of full rate with the exception of mixture MCPA + fluroxypyr. *Polygonum lapatifolium* was effectively eliminated by 25% of recommended rate of metribuzin + amidosulfuron, tribenuron-methyl with adjuvant, 2,4-D + fluroxypyr and 50% of rate 2,4-D + florasulam, amidosulfuron + iodosulfuron and also 75% of full rate of MCPA + fluroxypyr. Very good control of *Polygonum convolvulus* was observed after the application of half rate of tribenuron-methyl with adjuvant and amidosulfuron + iodosulfuron. The same effect was ensured by the use of MCPA + fluroxypyr and 2,4-D + florasulam at a rate reduced by 25% and by the application of full rate metribuzin + amidosulfuron and 2,4-D + fluroxypyr.

The best effect of *Stellaria media* control was given by amidosulfuron + iodosulfuron and tribenuron-methyl with an adjuvant irrespective of applied rate. Metribuzin + amidosulfuron and 2,4-D + florasulam had the desired efficacy only at full, 75% and half rates whereas 2,4-D + fluroxypyr at full rate and lowered by 25%. The weakest effect of *S. media* control was observed after MCPA + fluroxypyr mixture application even at full recommended rate (Tables 2, 3).

In the case of *Thlaspi arvense* all tested herbicides irrespective of applied rate were very effective. Only metribuzin + amidosulfuron at the rate reduced by 75% was less efficient (Tables 2, 3).

The application of amidosulfuron + iodosulfuron at a rate reduced by 50% allowed effective control of *Veronica persica*. The similar effects were observed after the use of metribuzin + amidosulfuron at a rate reduced by 50% and at full recommended rate of MCPA + fluroxypyr, 2,4-D + florasulam and tribenuron-methyl with adjuvant. The weakest effect of *V. persica* control was observed after the application of the mixture 2,4-D + fluroxypyr. The full recommended rate of this herbicide was insufficiently effective against this weed species (Tables 2, 3).

Vicia cracca was very sensitive to all investigated herbicides at all tested rates.

Viola arvensis responded differently to examined herbicides, regardless of the rates applied. The best effect of *V. arvensis* control was observed after application of amidosulfuron + iodosulfuron at a rate reduced by 50%. The similar results were obtained when applying MCPA + fluroxypyr at a rate lowered by 25% and after the treatment with the the full rate of 2,4-D + florasulam, 2,4-D + fluroxypyr and tribenuron-methyl with an adjuvant. The effect of *V. arvensis* control was insufficient even after the full rate of metribuzin + amidosulfuron (Tables 2, 3).

Influence on the yields of spring cereals

Grain yield of spring wheat and spring barley slightly differed among the herbicides treatments. The yield obtained from the untreated control was significantly lower compared to yields from treated plots (Fig. 2, 3).

The yield of spring wheat treated with examined herbicides oscillated at a level of 4.82–5.24 t ha^{-1}. In the case of spring barley it was from 5.47 to 5.97 t ha^{-1}.

The yields from untreated plots were 3.90–4.40 t ha^{-1} for spring wheat and 3.97–3.99 t ha^{-1} for spring barley.

DISCUSSION

Herbicide effectiveness depends on many factors including: susceptibility of weed to the herbicide applied, growth stage of weed, degree of weed infestation, crop condition, weather factors and application technology.

The study showed that the majority of weed species occurring in spring wheat and spring barely were effectively eliminated with the herbicides applied at the rates reduced by 25–50%. Some of them reacted similarly if a herbicide was used at rates lowered as much as 75%, e.g. *Anthemis arvensis, Brassca napus, Chenopodium album, Myosotis arvensis, Polygonum lapatifolium, Polygonum persicaria, Thlaspi arvense* and *Vicia cracca.* Similar effect was observed in the trials carried out in soil and climatic conditions of Lithuania by Auskalnis (2003). The author achieved success applying herbicides at rates reduced by 25–50% in the spring barley.

There was no significant statistical decrease of grain yield of spring cereals in treatments involving herbicides applied at rates reduced by 25–75%. The results of trials conducted in many countries (Davies et al., 1989; Kudsk, 1989; Schwarz, 2004; Whiting et al., 1991) demonstrated a high efficacy of herbicides used at rates reduced from 50% to 60%, without significant decrease of weed control efficacy or compromising grain yields of spring wheat and barley.

CONCLUSIONS

1. The tested herbicides were characterised by certain diversification of the weed control in reference to investigated weed species and rates.
2. The best results in controlling the weeds in spring cereals gave tribenuron methyl with adjuvant which excellently reduced fresh mass of weeds when applied at 25% of recommended rate. The same effect was observed after application half of recommended rate of the mix-

tures 2,4-D + florasulam, amidosulfuron + iodosulfuron, amidosulfuron+metribuzin and 2,4-D + fluroxypyr. Similar results occurred after application of mixture MCPA + fluroxypyr at of 75% the recommended rate.

3. Application of herbicides in the rate reduced by 25% to 75% in comparison to the recommended rate did not have significant impact on spring barely and spring wheat grain yield.

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