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THE POSSIBILITY OF WEED CONTROL IN CEREALS BY USE LOW RATES OF HERBICIDES – REVIEW OF EXISTING INVESTIGATIONS

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Abstract: In the years 1996–2002 evaluation of herbicides' efficacy used in low doses was tested. For investigations several herbicides recommended for weed control in cereals were selected. The results of experiments indicate on possibility of reducing of herbicides' doses by about 25 to 37.5%, and still obtaining good effects of weed control without significant decrease of yielding of cultivation plants. The dose is depended upon sensitivity of weed species, growth stage of weeds and their infestation, density of crop and the weather conditions. Low doses of herbicide can be applied where weeds are in early growth stage, where there is low infestation of weeds, and weeds show susceptibility to used herbicides, moreover under correct crop density and good weather conditions.

Key words: herbicides, reduced doses, cereals, regulation of weed infestation

INTRODUCTION

For maintaining the high yielding of grain crops, with good quality features of the grain, it is necessary to protect the plantation from the plant diseases, pests and weeds. As a result, every year the significant amounts of pesticides are brought to the cultivable fields during the phytosanitary treatments, among which the amounts of herbicides are the largest. Therefore, in the countries with agriculture cultivation systems being managed according to the rule of good agricultural practice, there is a trend to decrease (even by 50%) the use of pesticides. Great Britain, France and the Scandinavian countries (Sweden, Norway, Denmark) are the leaders among the European countries. In those countries the herbicide treatments with the use of doses reduced by 10 to 70% in comparison to the maximal recommended ones have become a standard by now, and the full doses are applied occasionally, only in strictly justified cases, when there is the clear recommendation of the advisor (Gauvrit 1991; Proven et al. 1991; Thonke 1991; Whiting et al. 1991).

The tendency to reduce the use of the 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 the influence on the improvement of their quality (Domaradzki and Rola 2000). Poland, as far, does not belong to the first rank countries, which are characterised by the highest use of the pesticides, however, the problem of reduction of the doses of the used herbicides is worth considering more closely (Rola et al. 1997).

The effective application of herbicides in reduced doses depends on some basic factors (Domaradzki and Rola 2001), such as: sensitivity of the weed to used herbicide, the growth stage of the weed, the state and degree of weed infestation, 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 doses may ensure obtaining good effectiveness of weed control and high yielding.

The aim of the following thesis was the analysis of the factors influencing the effectiveness and the assessment of the possibility of weed control with the use of reduced doses of herbicides.

MATERIALS AND METHODS

During the years 1996–2002 a lot of experiments were conducted, where the possibility of control of weed infestation of cereals with the use of several herbicides with the reduced doses was analysed. To illustrate the obtained results the seven of them were chosen and their characteristics are presented in table 1.

Within the framework of the experiment, the field experiments and micro-field and greenhouse ones were conducted. The experiments of the first kind were conducted on the farmers' fields, on the Lower Silesia (brown soil of class II – III b, podsolic soil of class III a – IV b, and black soil of class II – III a). The experiment was conducted with the use of the method of random choice of blocks, in three replications, on the 20 m^2 plots. The herbicides were applied in three doses – in the maximal recommended dose and in two reduced ones. The herbicides were applied with the use of rucksack sprayer "Gloria", with the constant pressure of 0.25 MPa and the expenditure of the spray liquid of 250 l/ha. The application was conducted in the spring, at the tillering growth stage of cereals, in the recommended terms for

Table 1. Characteristic of tested herbicides

Herbicide	Active ingredient	Full recommended dose [l, kg/ha]
Aminopielik D 450 SL	2,4-D 417.5 g/l; dicamba 32.5 g/l	3.0
Aurora Super 61,5 WG	carfentrazone-ethyl 1.5%; mecoprop-P 60%	1.0
Affinity 50,75 WG	isoproturon 50%; carfentrazone-ethyl 0.75%	2.75
Arelon Forte 61,5 WP	fluoroglycofen ethyl 1.5%; isoproturon 60%	2.0
Chwastox Trio 540 SL	dicamba 40 g/l; MCPA 200 g/l; mecoprop 300 g/l	2.0
Granstar 75 DF	tribenuron methyl 75%	2.0
Starane 250 EC	fluroxypyr 250g/l	0.8

each herbicide. The trials were harvested by the field mini-combine Nurserymaster Elite Z 035 at the stage of full ripeness.

In the micro-field experiments the influence of the sewing density of the winter wheat and the level of weed infestation on the effectiveness of weed control were assessed. The experiments were conducted on the 1 m^2 micro-fields, in the Department of Ecology and Weed Control of the Institute of Soil Science and Plant Cultivation in Wrocław.

In the pot experiments in the greenhouse, the influence of the development stage and the simulated precipitation on the effectiveness of weed control of the differentiated doses of herbicides were estimated. The assessment of the herbicides' effectiveness was calculated basing on the reduction of the fresh matter of weeds compared to the one from the untreated plots.

RESULTS AND DISCIUSSION

1. Factors influencing the effectiveness of treatment

Assessing the possibility of the weed infestation control in cereals with the reduced doses of herbicides, in the first place the influence of the most important factors on the effectiveness of the herbicide treatment must be taken into account.

A) The sensitivity of the weed to the used herbicide (Tab. 2)

Table 2. Reduction of fresh weight of *G. aparine* (BBCH=13–14) at different doses of tested herbicides

Dept. of Ecology and Weed Control, ISS&PC Wrocław 2001–2002

Herbicide	Reduction of fresh weight [%]			
	1/1 dose	3/4 dose	1/2 dose	1/4 dose
Starane 250 EC	95.4	94.0	93.9	89.7
Granstar 75 WG	51.6	52.7	27.2	10.4

One of the main rules of the application of reduced doses for the weed control is their use only against the species sensitive to the full recommended dose of the particular herbicide. In the case of partial effectiveness of the recommended doses even insignificant reduction is not justifiable, because the effectiveness of weed control will not be satisfactory. The good illustration of this phenomenon will be the comparison of reduction of fresh matter of *Galium aparine* by Starane 250 EC and Granstar 75 WG. The first of the mentioned herbicides was effective in controlling the weeds even in the lowest does, meaning the one reduced by 75% in comparison to the full recommended dose, however, the other one showed very low effectiveness even in the case of the full dose.

B) The development stage of the weed (Tab. 3)

The tendency of decrease of the efficacy of weed control by herbicides with the advanced growth stage of weeds is observed. Some departures from this rule may be observed when lowest doses (1/4) of herbicides are applied. It was observed sometimes, that the higher weed control activity of herbicides did not occur in the case of the youngest weeds, being at the cotyledon growth stage, but in the case of

Table 3. Reduction of fresh weight of weeds [%] at different doses of herbicides depending on weed growth stage

Dept. of Ecology and Weed Control, ISS&PC Wrocław 2001–2002

Herbicide	Dose	*Galium aparine*			*Stellaria media*		
		BBCH= 10–11	BBCH= 12–13	BBCH= 14–15	BBCH= 12–14	BBCH= 16–18	BBCH= 19–20
Starane 250 EC	1/1	97.8	95.4	92.6	100	97	98.3
	3/4	97.9	94	94.5	100	96.6	96,7
	1/2	97.8	93.9	92.5	92.2	96.2	94.5
	1/4	97.6	89.7	87.8	89.1	94.6	93.9
Chwastox Trio 540 SL	1/1	84.2	92.8	89.7	100	97.4	96.5
	3/4	71.2	91.4	84.2	100	97.3	95.9
	1/2	68	58.2	73.1	100	90.1	93.5
	1/4	45.4	35	40.2	100	83.4	83.6

slightly older plants, having the first specific leaves developed, as it occurred in the case of *G. aparine* and the herbicide Chwastox Trio 540 SL. It may be explained by the better penetration of the active ingredient through the specific leaves, than through the leather-like, covered with the waxen coating, cotyledons.

C) The level of weed infestation (Tab. 4)

The intensity of the weed infestation in the field is the important factor. The fewer weeds can be found in the plantation, the higher effectiveness of the used

Table 4. Weed control efficacy [%] of herbicides depending upon number of selected weeds

Dept. of Ecology and Weed Control, ISS&PC Wrocław 1996–2000

Herbicide	Dose (l. kg/ha)	*Galium aparine*				*Stellaria media*			
		< 10 plants per sq. meter	11–20 plants per sq. meter	21–50 plants per sq. meter	>50 plants per sq. meter	< 10 plants per sq. meter	11–20 plants per sq. meter	21–50 plants per sq. meter	>50 plants per sq. meter
Chwastox Trio 540 SL	2	98	97	95	94	100	96	96	94
	1.75	95	94	92	91	96	96	92	92
	1.5	92	90	88	81	92	92	91	89
Starane 250 EC	0.8	100	99	97	91	100	99	95	90
	0.6	98	97	96	86	100	99	95	89
	0.4	98	97	96	87	100	99	93	65
		Apera spica-venti				*Stellaria media*			
		< 20 plants per sq. meter	21–50 plants per sq. meter	51–100 plants per sq. meter	> 100 plants per sq. meter	< 10 plants per sq. meter	11–20 plants per sq. meter	21–50 plants per sq. meter	>50 plants per sq. meter
Affinity 50,75 WG	2.75	100	98	95	91	100	98	96	91
	2	97	92	90	84	99	96	94	83
	1.5	94	86	85	76	98	90	81	56
	2	98	98	96	90	100	99	99	98
	1.5	97	94	93	85	100	99	97	64
	1	90	86	82	68	91	90	86	59

herbicides. It results from the fact that the weed control performance of the herbicide is aided by the competitive influence of the crop, which lowers together with the increase of weed infestation.

D) The population density and condition of cultivated crop (Tab. 5)

Table 5. Reduction of fresh weight of *G. aparine* at different doses of herbicides depending upon winter wheat density

Dept. of Ecology and Weed Control, ISS&PC Wrocław 2001–2002

Herbicide	Dose	Winter wheat infestation – plants per sq. meter	
		225 plants per sq. meter	450 plants per sq. meter
Untreated	–	155.8 g/m^2*)	107.9 g/m^2*)
Chwastox Trio 540 SL	1/1	95.7%	97.1%
	3/4	89.8%	94.6%
	1/2	79.5%	84.1%
	1/4	54.1%	57.2%
Starane 250 EC	1/1	99.0%	100%
	3/4	97.6%	98.8%
	1/2	95.4%	97.2%
	1/4	89.7%	89.9%

*) fresh weight of *G. aparine*

The crop growing in the optimal density, in the conditions ensuring its proper development and health and potentially high level of yielding, possesses the defence mechanism, which is the competitive influence on the weeds occurring in the field. For example the decrease of density of winter wheat from 450 plants per sq. meter to 225 plants per sq. meter caused the increase of the fresh matter of *G. aparine* by 44.4%, moreover, the decrease of effectiveness of herbicides in the case of the field of the lower density was observed, especially when the reduced doses were used.

E) The weather conditions (Tab. 6.)

The application of the herbicide in the reduced dose must be performed in the favourable weather conditions. The precipitation in amount of 5 mm (in 10 minutes time) occurring after 1 and 3 hours after the treatment simulated in the experiments did not influence the effectiveness of the herbicide Aurora Super 61,5 WG applied in the full dose, however it significantly lowered the effectiveness of the re-

Table 6. Reduction of fresh weight of *G. aparine* at different doses of Aurora Super 61.5 WG depending upon rainfall time after application

Dept. of Ecology and Weed Control, ISS&PC Wrocław 2001–2002 (according to R. Kieloch manuscript)

Herbicide	Dose	Reduction of fresh weight by herbicide [%]			
		without rainfall	1 hour after treatment	3 hours after treatment	6 hours after treatment
Aurora Super 61,5 WG	1/1	99	96	98	100
	1/2	92	77	85	96
	1/4	79	25	66	82

Amount of rainfall – 5 mm during 10 minutes

duced doses. The similar relations were not observed when the precipitation occurred 6 hours after the treatment.

2. The effectiveness of weed control of the reduced doses of herbicides and their influence on the yielding.

The tested herbicides were characterised by certain diversification of the effectiveness resulting from the recommended dose. In the case of the Aminopielik D 450 SL and Starane 250 EC, designed for treating the dicotyledonous species, the difference in effectiveness between the full dose and the lowest one amounted to 3 up to 8% (Tab. 7). The best effectiveness of weed control was observed in the winter wheat and the winter triticale and in the spring cereals, and definitely the effectiveness was lower in the winter barely, which resulted from the fact that the weeds in this grain crop were more developed during the treatment in comparison to other cereals. The statistical analysis of the yielding showed that the reduction of the dose of herbicides Aminopielki D 450 SL (by 33%) and Starane 250 EC (by 50%) did not influence the yielding of the winter and spring cereals (Tab. 7). Statistically the significant differences in yielding were only observed between the objects treated with the two highest doses and the lowest dose of Affinity 50,75 WG in the winter triticale and the winter barely and of Arelon Forte 61,5 WP in the winter triticale. In the winter wheat the reduction of the dose of Affinity 50,75 WG by 37.5% and Arelon Forte 61,5 WP by 25% did not cause the significant decrease in yielding of the crop (Tab. 8).

The herbicides Affinity 50,75 WG and Arelon Forte 61,5 WP, regardless of the used dose, controlled *Apera spica-venti* (L.) Pal. Beauv. very well (in 92–99%) in the winter wheat and in the winter triticale, a bit less effectively in the winter barely (87–95%) – table 8. The dicotyledonous weeds were eliminated significantly poorer, which resulted from the high amount of weeds belonging to this group in the field and from not full effectiveness of the herbicides under experiments in relation to *Geranium pusillum* L. and *Viola arvensis* Murr., which species had recognisable share in the weed infestation and were poorly controlled.

CONCLUSIONS

Basing on the conducted experiments the following may be concluded:

1. The use of the herbicides in the reduced doses was dependent on the sensitivity of the weed to the used herbicide, its growth stage, the intensity of occurrence in the field, the condition of the crop and the weather conditions.
2. The reduction of the doses of the herbicides: Aminopielik D 450 SL, Starane 250 EC, Affinity 50,75 WG and Arelon Forte 61,5 WP by 25 up to 37.5% did not influence significantly the level of yielding of the cereals, and did not have the negative influence on the effectiveness of weed control.
3. Better effectiveness of the reduced doses of herbicides was observed on the fields of low intensity of weed infestation, in the case of controlling the species sensitive to the particular herbicide and when the weeds were in the early growth stage.
4. The proper density of the cultivated plant facilitates the higher effectiveness of the use of reduced doses and the optimal weather conditions on the day of application.

Table 7. Evaluation of different doses of Aminopielik D 450 SL and Starane 250 EC and their influence on cereals' yielding

Dept. of Ecology and Weed Control, ISS&PC Wrocław 1997–2002

Herbicide	Dose per ha	Winter wheat		Winter barley		Triticale		Spring wheat		Spring triticale	
		yield t/ha	w.c. 2	yield t/ha	w.c. 2	yield t/ha	w.c. 2	yield t/ha	w.c. 2	yield t/ha	w.c. 2
Untreated	–	5.46	78 pl/m^2	5.00	149 pl/m^2	3.56	154 pl/m^2	3.37	78 pl/m^2	5.21	184 pl/m^2
Aminopielik D 450 SL	2.0	6.15	89	5.76	83	4.29	91	3.62	92	5.65	88
Aminopielik D 450 SL	2.5	6.25	93	5.97	85	4.35	92	3.73	94	5.70	92
Aminopielik D 450 SL	3.0	6.33	94	6.13	87	4.46	95	3.81	97	5.89	94
LSD (0.05)		0.197		0.494		0.196		0.195		0.251	
Untreated	–	4.96	76 pl/m^2	6.37	237 pl/m^2	3.75	207 pl/m^2	3.27	90 pl/m^2	4.57	203 pl/m^2
Starane 250 EC	0.4	5.95	88	6.93	86	4.90	80	3.69	87	5.07	86
Starane 250 EC	0.6	6.05	90	6.96	88	5.01	81	3.72	90	5.08	92
Starane 250 EC	0.8	6.19	92	7.21	89	5.19	88	3.78	94	5.09	94
LSD (0.05)		0.249		0.280		0.317		0.140		0.079	

Table 8. Evaluation of different doses of Affinity 50,75 WG and Arelon Forte 61,5 WP and their influence on cereals' yielding

Dept. of Ecology and Weed Control, ISS&PC Wrocław 1998–2002

Herbicide	Dose per ha	Winter wheat			Winter barley			Triticale		
		yield t/ha	w.c. 1	w.c. 2	yield t/ha	w.c. 1	w.c. 2	yield t/ha	w.c. 1	w.c. 2
Untreated	–	4.39	135 pl/m^2	160 pl/m^2	4.76	54 pl/m^2	150 pl/m^2	4.44	77 pl/m^2	294 pl/m^2
Affinity 50,75 WG	1.5	5.12	92	78	5.39	88	75	5.55	97	68
Affinity 50,75 WG	2	5.23	96	80	5.51	91	87	5.63	99	71
Affinity 50,75 WG	2.75	5.37	98	83	5.73	94	91	5.88	99	77
LSD (0.05)		0.269			0.223			0.232		
Untreated	–	3.71	145 pl/m^2	154 pl/m^2	4.46	70 pl/m^2	170 pl/m^2	4.17	79 pl/m^2	346 pl/m^2
Arelon Forte 61,5 WP	1.5	4.55	97	75	5.64	87	72	4.99	95	64
Arelon Forte 61,5 WP	1.75	4.63	98	83	5.81	90	81	5.37	95	77
Arelon Forte 61,5 WP	2.0	4.75	99	87	5.86	94	81	5.55	97	82
LSD (0.05)		0.370			0.402			0.286		

w.c. 2 – control of broad leaves weeds in%
w.c. 1 – control of grass weeds in%
pl/m^2 – plants per sq. meter

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POLISH SUMMARY

MOŻLIWOŚĆ REGULACJI ZACHWASZCZENIA ZBÓŻ NIŻSZYMI DAWKAMI HERBICYDÓW W ŚWIETLE DOTYCHCZASOWYCH BADAŃ

W latach 1996–2002 przeprowadzono kilkadziesiąt doświadczeń, w których analizowano możliwość regulacji zachwaszczenia zbóż za pomocą kilkunastu herbicydów stosowanych w zbożach, w dawkach niższych od zalecanych. Na ich podstawie można stwierdzić, że istnieje możliwość obniżenia dawek badanych herbicydów o 25 do 37,5%, bez istotnego obniżenia plonowania rośliny uprawnej, przy zachowaniu wymaganej skuteczności chwastobójczej.

Wysokość dawki herbicydu jest przede wszystkim uzależniona od wrażliwości chwastów, ich fazy rozwojowej oraz nasilenia, stanu zagęszczenia i kondycji rośliny uprawnej oraz warunków pogodowych.

Zabieg niższymi dawkami przynosi najlepsze efekty na polach, gdzie występują chwasty we wczesnych fazach, ich nasilenie jest niewielkie, a gatunki w łanie są wrażliwe na stosowany herbicyd, a także w przypadku właściwej obsady i dobrej kondycji rośliny uprawnej oraz w czasie sprzyjających warunków pogodowych.