The influence of selected spraying parameters on two formulation of sulfonylurea herbicides effect

Wpływ wybranych parametrów opryskiwania na skuteczność dwóch form użytkowych herbicydów sulfonylomocznikowych

Renata, KIELOCH* and Krzysztof, DOMARADZKI

Institute of Soil Science and Plant Cultivation – Research State Institute, Department of Weed Science and Tillage Systems, Orzechowa 61, 50-540 Wrocław, e-mail: r.kieloch@iung.wroclaw.pl*, phone: +48 (71)363 83 07

Abstract

The objective of this study was the evaluation of spray volume and nozzle type effect on different formulation (water dispersible granules - WG and oil dispersion - OD) of two sulfonylurea herbicides: the mixture iodosulfuron methyl sodium + amidosulfuron and iodosulfuron methyl sodium + mesosulfuron methyl efficacy. There were investigated three levels of spray volume (125 l*ha^{-1}, 250 l*ha^{-1} and 350 l*ha^{-1}) and two types of nozzle (extended range flat nozzle TeeJet XR 11003-VS and drift guard flat nozzle TeeJet DG 11003-VS). Each herbicide was used at recommended dose and reduced by half. Spray volume and nozzle type did not affect activity of the mixture iodosulfuron methyl sodium + amidosulfuron, but differentiated the efficacy of OD formulation of iodosulfuron methyl sodium + mesosulfuron methyl, when it was applied at lowered dose. As spray volume rose, herbicide efficacy decreased. Nozzle type influenced OD formulation of the mixture iodosulfuron methyl sodium + mesosulfuron methyl, independently on dose. Significantly weaker efficacy was obtained when drift guard nozzle was used.

Keywords: dose, efficacy, formulation, spray volume, sulfonylurea herbicide, type of nozzle

Streszczenie

Celem badań była ocena wpływu wydatku cieczy użytkowej i rodzaju dysz opryskiwacza na różne formy użytkowe (granulat do sporządzania zawiesiny wodnej – WG i zawiesina olejowa do rozcieńczania wodą – OD) dwóch herbicydów sulfonylomocznikowych: mieszaniny jodosulfuron metylosodowy + amidosulfuron oraz mieszaniny jodosulfuron metylosodowego z mezosulfuronem metylowym. Oceniano trzy poziomy wydatku cieczy użytkowej (125 l*ha^{-1}, 250 l*ha^{-1} i 350 l*ha^{-1}) oraz dwa rodzaje dysz opryskiwacza (dysza płaskostrumieniowa o rozszerzonym zakresie ciśnienia TeeJet XR 11003-VS i dysza płaskostrumieniowa z zabezpieczeniem przed znoszeniem TeeJet DG 11003-VS). Badane środki zastosowano w dawce zalecanej oraz obniżonej o połowę. Wydatek cieczy użytkowej oraz rodzaj dysz opryskiwacza nie wpłynęły na działanie mieszaniny jodosulfuron metylosodowy + amidosulfuron. Wydatek cieczy użytkowej zróżnicował skuteczność formy olejowej (OD) mieszaniny jodosulfuronu metylosodowego z mezosulfuronem metylu aplikowanego w dawce zredukowanej. Wraz ze wzrostem wydatku cieczy użytkowej, malała skuteczność herbicydu. Rodzaj dysz wpłynął na skuteczność działania formy OD powyższej mieszaniny, niezależnie od dawki. Znacząco słabszą skuteczność osiągnięto, gdy zastosowano dyszę antyznoszeniową.

Słowa kluczowe: dawka, forma użytkowa, herbicydy sulfonylomocznikowe, rodzaj dyszy, skuteczność, wydatek cieczy użytkowej

Detailed abstract

Skuteczność działania herbicydu jest wypadkową wielu czynników. O końcowym efekcie chwastobójczym zastosowanego środka w dużym stopniu decyduje proces jego pobrania przez chwasty, od którego zależy ilość substancji aktywnej zaabsorbowanej przez roślinę. Właściwy dobór parametrów technicznych opryskiwania oraz właściwości fizyko-chemiczne cieczy użytkowej wpływa na dokładność pokrycia opryskiwanych powierzchni i jej retencję, a tym samym ilość pobranego herbicydu.

W ramach badań wykonano doświadczenia w warunkach kontrolowanych (szklarnia) nad oceną wpływu wydatku cieczy użytkowej i rodzaju dysz opryskiwacza na różne formy użytkowe (granulat do sporządzania zawiesiny wodnej – WG i zawiesina olejowa do rozcieńczania wodą – OD) dwóch herbicydów sulfonylomocznikowych: mieszaniny jodosulfuronu metylosodowego z amidosulfuronem oraz mieszaniny jodosulfuronu metylosodowego z mezosulfuronem metylowym. Dodatkowo, w badaniach nad wpływem wydatku cieczy użytkowej na skuteczność zabiegu przeprowadzono trzyletnie doświadczenia polowe, w dwóch lokalizacjach pszenicy ozimej, różniących się pod względem zachwaszczenia: 1. pole z dominacją gatunków jednoliściennych, 2. pole opanowane przez gatunki dwuliścienne. W badaniach oceniono trzy poziomy wydatku cieczy użytkowej (125 l*ha^{-1}, 250 l*ha^{-1} i 350 l*ha^{-1}) oraz dwa rodzaje dysz opryskiwacza (dysza płaskostrumieniowa o rozszerzonym zakresie ciśnienia TeeJet XR 11003-VS i dysza płaskostrumieniowa z zabezpieczeniem przed znoszeniem (TeeJet DG 11003-VS). Herbicydy zastosowano w dawkach zalecanej oraz obniżonej o połowę. Dawki mieszaniny jodosulfuron metylosodowy + mezosulfuron metylowy wynosiły 2.4 g*ha^{-1} + 12 g*ha^{-1} i 1.2 g*ha^{-1} + 6 g*ha^{-1}, a mieszaniny jodosulfuron metylosodowy + amidosulfuron 3.75 g*ha^{-1} + 15 g*ha^{-1} i 1.875 g*ha^{-1} + 7.5 g*ha^{-1}. Zabieg herbicydowy w badaniach szklarniowych wykonano, gdy chwasty znajdowały się we wczesnych fazach rozwojowych (2-4 liście). W badaniach polowych faza rozwojowa zawierała się w granicach 4-10 liści.

Wydatek cieczy użytkowej oraz rodzaj dysz opryskiwacza nie wpłynęły na działanie mieszaniny jodosulfuron metylosodowy + amidosulfuron. Wydatek cieczy użytkowej zróżnicował skuteczność formy olejowej (OD) mieszaniny jodosulfuronu metylosodowego z mezosulfuronem metylu aplikowanego w dawce zredukowanej. Wraz ze wzrostem wydatku cieczy użytkowej, malała skuteczność herbicydu. Rodzaj dysz wpłynął na skuteczność działania formy OD powyższej mieszaniny, na poziomie obu badanych dawek. Znacząco słabszą skuteczność osiągnięto, gdy zastosowano dyszę antyznoszeniową. Wpływ ocenianych parametrów technicznych zabiegu był znacznie silniejszy w przypadku gatunku mniej wrażliwego na powyższą mieszaninę, tj. *Alopecurus myosuroides*.

Introduction

Current tendency in plant protection tends to enhance herbicide efficacy, reducing of pesticides active ingredients introduction to arable fields, simultaneously. In weed control main role plays herbicide uptake, because this process determines amount of active ingredients absorbed by weeds and translocated to the target site of action.

Appropriate selection of spraying parameters affects accuracy of spraying surfaces coverage by herbicide solution and consequently quantum of retained and absorbed herbicide active ingredient. In weed control, herbicide formulation is an important determinant of its active ingredient activity by building up its physicochemical properties (Zabkiewicz, et al. 2007). Current research performances trends towards attainment of herbicide formulation characterized by better spray solution retention, spreading on the leaves surfaces and absorption by weeds - properties finally affecting herbicide effectiveness. To achieve high weed control level, some of herbicides require addition of adjuvants. These compounds enhance herbicides activity by increase of cuticule permeability, reduction of surface tension, increase of spray solution adhesion, prevention of herbicide crystalisation on leaves surface (Green and Beestman, 2007). Joint application of herbicide and adjuvant enables reduction of herbicide dose without risk of weed control decrease (Collins and Helling, 2002, Stagnari, et. al., 2006).

Spraying parameters, such as spray volume and type of nozzle, play a important role in weed control effect because of their influence on covering and distribution of spray solution on plants surfaces (Kierzek and Wachowiak, 2009, Stainer, et al., 2006).

The objective of this study was the evaluation of some spraying parameters on different formulation (water dispersible granules - WG and oil dispersion - OD) of two sulfonylurea herbicides: the mixture iodosulfuron methyl sodium + amidosulfuron and iodosulfuron methyl sodium + mesosulfuron methyl efficacy.

Material and methods

Research included two type of experiment:

1. evaluation of the influence of spray volume (125 l*ha^{-1}, 250 l*ha^{-1} and 350 l*ha^{-1}) on herbicide efficacy was performed under both glasshouse and field conditions,
2. evaluation of type of nozzle (extended range flat nozzle TeeJet XR 11003-VS and drift guard flat nozzle TeeJet DG 11003-VS) on herbicide effect was carried out in glasshouse.

Glasshouse experiments involved five weed species as tested plants, that were planted into plastic, 10 cm diameter pots, filled with the mixture of peat and sand. The experimental pattern was completely randomization, in three replications. Grass weeds (*Apera spica-venti* L., *Alopecurus myosuroides* Huds.) were sprayed by the mixture iodosulfuron methyl sodium + mesosulfuron methyl, that is primarily aimed to grass and small number of broadleaved weeds control. Plants of *Anthemis arvensis* L., *Galium aparine* L. and *Thlaspi arvense* L. were treated by iodosulfuron methyl sodium + amidosulfuron, that is appropriate to control of broadleaved weeds. At the time of herbicide treatment weeds were at early growth stages (2-4 leaves). Field experiments were carried out during three growing seasons (2007-2009), at two locations of winter wheat, that varied with respect to weed infestation. At the first experimental site, wheat was mainly infested by grass and small number of broadleaved weeds, therefore plots were sprayed by the mixture iodosulfuron methyl sodium + mesosulfuron methyl. At the second location, that was infested by broadleaved weeds, the mixture iodosulfuron methyl sodium + amidosulfuron was used. The experiments followed by the randomized blocks pattern, with four replications. Herbicides treatment was made at the full tillering of wheat, when weeds growth stage varied between 4 and 10 leaves.

Each herbicide was used at recommended dose and reduced by half. The mixture iodosulfuron methyl sodium + mesosulfuron methyl was applied at rates 2.4 g*ha^{-1} + 12 g*ha^{-1} and 1.2 g*ha^{-1} + 6 g*ha^{-1}. According to producer recommendation, WG formulation of this mixture was applied in combination with adjuvant Actirob 842 at dose 1 l*ha^{-1}, to ensure high effect of weed control. Investigated rates of the mixture iodosulfuron methyl sodium + amidosulfuron amounted to 3.75 g*ha^{-1} + 15 g*ha^{-1} and 1.875 g*ha^{-1} + 7,5 g*ha^{-1}. Herbicide application under glasshouses conditions was made using laboratory sprayer "Aporo". Experiment 1 was performed using standard nozzle (TeeJet XR 11003-VS) operated at different speed and pressure to obtain three levels of spray volume: (125 l*ha^{-1}, 250 l*ha^{-1} and 350 l*ha^{-1}). Field experimental plots were sprayed by knapsack sprayer "Gloria" equipped with standard - TeeJet XR 11003-VS nozzles. At experiment 2, sprayer operated at constant speed of 2,5 km/ha and the pressure of 200 kPa, producing standard spray volume of 250 l*ha^{-1}.

Three weeks after herbicides treatment, weeds were harvested from each pot or field plots and their fresh weight was determined. Herbicides efficacy was assessed on the base of fresh weight reduction influenced by herbicides activity in comparison with untreated object. The fresh weight value of individual weed species (per pot) was calculated as percentage of untreated object and then transformed according to Bliss pattern. For the field experiments calculation, total value of all weeds fresh weight obtained from each plot. The transformed data was calculated using analysis of variance procedures to evaluate the significance of differences at level 0.05.

Results

Considering the influence of herbicide formulation, the mixture iodosulfuron methyl sodium + mesosulfuron methyl was more efficient against weeds, when was applied as water dispersible granules compare to oil dispersion and its activity was more dependent on examined spraying parameters. Another tested herbicide, the mixture iodosulfuron methyl sodium + amidosulfuron did not prove differences with respect to formulation, at type of nozzle as well as spray volume study.

Spray volume affected the activity of the mixture iodosulfuron methyl sodium + mesosulfuron methyl, resulting in decrease of efficacy as along spray volume rose. Significant differences only in case of reduced dose application of oil formulation of this mixture were observed. Control of *A.myosuroides* was more dependent on spray volume than control of *A. spica-venti*. Comparable weed control effect at recommended and also reduced dose level was obtained for the lowest (125 l*ha^{-1})

spray volume (Table 1 a). Efficacy of the mixture iodosulfuron methyl sodium + amidosulfuron was not related to spraying volume (Table 1 b). Field experiment resulted in weaker efficacy at the highest spray volume for both rates of OD iodosulfuron methyl sodium + mesosulfuron methyl (Table 2).

Table 1. The influence of spray volume on the efficacy of two formulation of sulfonylurea herbicides: a. iodosulfuron methyl sodium + mesosulfuron methyl, b. iodosulfuron methyl sodium + amidosulfuron
Tabela 1. Wpływ wydatku cieczy użytkowej na efektywność dwóch form użytkowych herbicydów sulfonylomocznikowych: a. jodosulfuron metylosodowy + mezosulfuron metylowy, b. jodosulfuron metylosodowy + amidosulfuron

a.

Spray volume Wydatek cieczy użytkowej (l*ha^{-1})	Efficacy Skuteczność (%)							
	A. spica-venti				*A. myosuroides*			
	WG		OD		WG		OD	
	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD
125	99a	99a	99a	96a	90a	87a	88a	86a
250	98a	98a	98a	95a	90a	86a	87a	76b
350	99a	99a	99a	85b	86a	83a	89a	68c

FD (full dose – dawka pełna) – 2.4 g*ha^{-1} + 12 g*ha^{-1} , ½ FD (reduced dose – dawka zredukowana) – 1.2 g*ha^{-1} + 6 g*ha^{-1}

b.

Spray volume Wydatek cieczy użytkowej (l*ha^{-1})	Efficacy Skuteczność (%)											
	A. arvensis				*G. aparine*				*T. arvense*			
	WG		OD		WG		OD		WG		OD	
	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD
125	95a	90a	90a	92a	92a	88a	95a	89a	95a	95a	96a	95a
250	96a	93a	93a	91a	92a	86a	94a	90a	96a	94a	97a	96a
350	96a	91a	93a	91a	92a	88a	94a	90a	95a	95a	96a	95a

FD (full dose – dawka pełna) – 3.75 g*ha^{-1} + 15 g*ha^{-1} , ½ FD (reduced dose – dawka zredukowana) – 1.875 g*ha^{-1} + 7.5 g*ha^{-1}

Values marked by the same letter do not differ significantly

Table 2. The influence of spray volume on the efficacy of two formulation of sulfonylurea herbicides on the base of field experiments (average from 2007-2009)
Tabela 2. Wpływ wydatku cieczy użytkowej na efektywność dwóch form użytkowych herbicydów sulfonylomocznikowych na podstawie badań polowych (2007-2009)

Spray volume Wydatek cieczy użytkowej ($l*ha^{-1}$)	Efficacy Skuteczność (%)							
	Iodosulfuron methyl sodium + mesosulfuron methyl				Iodosulfuron methyl sodium + amidosulfuron			
	WG		OD		WG		OD	
	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD
125	95a	91a	94a	89a	98a	95a	94a	94a
250	89a	88a	88a	85b	98a	96a	95a	93a
350	86b	85b	84b	80b	99a	96a	92a	94a

FD (full dose – dawka pełna) – 2.4 $g*ha^{-1}$ + 12 $g*ha^{-1}$ for iodosulfuron methyl sodium + mesosulfuron methyl and 3.75 $g*ha^{-1}$ + 15 $g*ha^{-1}$ for iodosulfuron methyl sodium + amidosulfuron
½ FD (reduced dose – dawka zredukowana) – 1.2 $g*ha^{-1}$ + 6 $g*ha^{-1}$ for iodosulfuron methyl sodium + mesosulfuron methyl and 1.875 $g*ha^{-1}$ + 7.5 $g*ha^{-1}$ for iodosulfuron methyl sodium + amidosulfuron
Values marked by the same letter do not differ significantly

Nozzle type did not affect grass weeds control, when plants were sprayed by WG formulation of the mixture iodosulfuron methyl sodium + mesosulfuron methyl. OD formulation was significantly influenced by type of nozzle when was applied at reduced dose. Usage of TeeJet DG 11003-VS gave considerably weaker *A. myosuroides* control than TeeJet XR 11003-VS, at both doses level. Parallel pattern was found for *A. spica-venti* treated with reduced dose. Oil formulation showed essential differences between recommended and reduced dose activity (Table 3 a). Nozzle type did not affect the mixture iodosulfuron methyl sodium + amidosulfuron activity (Table 3 b).

Table 3. The influence of nozzle type on the efficacy of two formulation of sulfonylurea herbicides a. iodosulfuron methyl sodium + mesosulfuron methyl, b. iodosulfuron methyl sodium + amidosulfuron
Tabela 3. Wpływ rodzaju dyszy na efektywność dwóch form użytkowych herbicydów sulfonylomocznikowych: a. jodosulfuron metylosodowy + mezosulfuron metylowy, b. jodosulfuron metylosodowy + amidosulfuron

a.

Nozzle type Rodzaj dyszy	Efficacy Skuteczność (%)							
	A. spica-venti				*A. myosuroides*			
	WG		OD		WG		OD	
	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD
TeeJet XR 11003-VS	96a	95a	97a	89a	90a	89a	91a	69c
TeeJet DG 11003-VS	90a	89a	92a	80b	91a	89a	83b	56d

b.

Nozzle type Rodzaj dyszy	Efficacy Skuteczność (%)											
	A. arvensis				*G. aparine*				*T. arvense*			
	WG		OD		WG		OD		WG		OD	
	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD	FD	½ FD
TeeJet XR 11003-VS	94a	93a	98a	95a	92a	77c	94a	89a	100a	100a	100a	100a
TeeJet DG 11003-VS	92a	86a	98a	97a	91a	74c	94a	92a	100a	100a	100a	100a

Explanations – see table 1 a, b
Objaśnienia – patrz tabela 1a, b

Discussion

Correctly application method should result in a great quantity of herbicide active ingredient deposited and uniformly distributed on plant surface. It can be obtained by optimizing of spraying parameters such as spray volume, nozzle type, size of droplets, herbicide dose and formulation. Results obtained from these experiments show, that herbicide efficacy was influenced by kind of active ingredient, herbicide dose and formulation, spray volume and nozzle type used in herbicide treatment.

Studies on the influence of spray volume on herbicides effect gave divergent results. Increase of this parameter leads to dilution of herbicide and reduction of spray solution retention on treated plants, giving herbicide effect decrease (Shaw, et al., 2000). McMullan (1995) reports, that reduction of spray volume caused increase of sethoxydim efficacy, but did not influence fenoxaprop-P- ethyl. For contrast, spray volume did not affect activity of trinexapac-ethyl, although higher efficacy at low volume level was observed when adjuvant was added to spray solution (Fagerness and Penner, 1998). In the present study, weaker efficacy with respect to herbicide formulation was observed for only iodosulfuron methyl sodium + mesosulfuron methyl. Activity of water dispersible granules formulation, that was applied under controlled conditions was not related to spray volume, but differences occurred only in case of oil formulation used in reduced dose. The OD is a new formulation that combines the advantages of solid and liquid formulations. Usage of oil dispersion formulation results in improvement of spray solution retention and its spreading on the leaves surface. Therefore it is expected, that activity of oil dispersion herbicides was not considerably related to other factors such as spraying parameters. However results of presented research are in disagreement with this assumption, but only with respect to iodosulfuron methyl sodium + mesosulfuron methyl. WG formulation was used, according to producer recommendation, with addition of adjuvant, whilst the same formulation of the second herbicide does not require usage of adjuvant. Thus joint application (WG formulation + adjuvant) was more profitable than single one (OD formulation alone). Efficacy of iodosulfuron methyl sodium + mesosulfuron methyl (WG and OD) applied under field conditions was dependent on spray volume for both recommended and reduced dose, resulting in weaker weed control at the highest spray volume. Proven differences between field and glasshouse experiments are due to higher herbicides activity under controlled environment conditions and also different at more advanced weeds growth stage and the time of spraying (Domaradzki and Kieloch, 2007). The efficacy of oil dispersion herbicide has also been reported for the mixture iodosulfuron methyl sodium + mesosulfuron methylsodium, giving better OD than WG effect (Kerlen and Brink, 2006), but other researcher did not find differences between formulation (Paradowski and Jakubiak, 2006).

Nozzle type affects size of droplets and also spray distribution on plant surface. Results obtained from this research proved better herbicide efficacy when TeeJet XR 11003-VS was used for treatment. These differences were found for only the mixture iodosulfuron methyl sodium + mesosulfuron methyl applied as oil formulation. More pronounced diversification for reduced rate was observed. Nozzle TeeJet DG 11003-VS is especially useful under windy weather conditions, because it produces larger droplets, that are less vulnerable to drift. Similarly to these findings, it was reported previously that better herbicide efficacy could be performed using nozzles producing small droplets (Kierzek and Wachowiak, 2005, Shaw, et al., 2000).

Reduced doses application imposes certain restriction and requires detailed information about the influence of numerous conditions on the efficacy of herbicide such as plants and soil-weather factors as well as technical parameters. Activity of herbicide used at lowered dose is more dependent on other factors, i.e. treatment carried out under unfavorable weather conditions or on later weeds growth stage can result in decrease of efficacy (Collings, et al. 2003, Domaradzki and Kieloch 2007). Therefore results obtained from this research point out that greater spray volume (350 l*ha^{-1}) and drift guard flat nozzle (TeeJet DG 11003-VS) may be factor limiting lowered dose application, especially against less responsive to herbicides weed species. It is also important to take into consideration active ingredient of herbicide and its formulation.

Conclusions

Water volume and nozzle type did not affect the mixture iodosulfuron methyl sodium + amidosulfuron activity.

Water volume differentiated efficacy of OD formulation of the mixture iodosulfuron methyl sodium + mesosulfuron methyl, when it was used at lowered dose. As water volume rose, herbicide efficacy decreased.

Type of nozzle influenced efficacy of OD formulation of the mixture methyl sodium + mesosulfuron methyl, at both of full and reduced doses level. Significantly weaker efficacy was obtained when drift guard nozzle was used.

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