Polish Journal of Agronomy
2012, 8, 15–19

Weed species response to two formulations of iodosulfuron methyl sodium and amidosulfuron mixture applied at various environmental conditions

Renata Kieloch, Mariusz Kucharski

Department of Weed Science and Tillage Systems in Wrocław
Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy
ul. Orzechowa 61, 50-540 Wrocław, Poland

Abstract. The pot experiments concerning the response of different weed species to two formulation of iodosulfuron methyl sodium and amidosulfuron mixture applied at different air temperature, relative humidity and soil moisture conditions were investigated in controlled environment chamber. The response of *Anthemis arvensis* L., *Galium aparine* L. and *Thlaspi arvense* L. was examined. Two levels of each climate factors were investigated: for temperature – 24/12 and 12/6°C, for humidity – 40 and 70%, for soil moisture – 30 and 60%. The herbicide was applied at a recommended dose of 3.75 g ha^{-1} iodosulfuron methyl sodium + 15 g ha^{-1} amidosulfuron and at two herbicide formulations – water dispersible granules (WG) and oil dispersion (OD). Response of the weed species to herbicide formulation was determined based on plant biomass reduction. *T. arvense* control did not depend on herbicide formulation, but it was affected by soil moisture, whereas *G. aparine* was strongly affected by relative humidity, soil moisture and herbicide formulation. Among the examined species, only *A. arvensis* response to herbicide was related to temperature. Efficacy of the WG formulation was more influenced by climate conditions, especially relative humidity and soil moisture. Plants of *G. aparine* and *A. arvensis* were more sensitive to OD than WG formulation, regardless of the climate factor.

key words: weed species, response, herbicide formulation, temperature, humidity, soil moisture, weed control

INTRODUCTION

Diversification in efficacy of foliar-applied herbicides under various climate and soil conditions may be closely related to environmentally-induced differences in herbicide uptake, translocation and metabolism in plants. In addition, the relationship between the final effect of individual herbicide and environment conditions also depends on its mechanism of action and on the controlled weed species. Weather conditions around the time of spraying influenced degree of weed control by changing plants morphology and spray solution action on treated surface. It was reported previously that under conditions conducive to both plants growth and development as well as to herbicide activity, weed control could be kept at a satisfactory level, whereas unfavourable conditions decreased its efficacy (Kudsk, 2001).

Iodosulfuron methyl sodium and amidosulfuron are sulfonylurea herbicides to control broad-leaved weeds in cereals. The mechanism of action of that herbicide is based on inhibition of the enzyme ALS (acetolactate synthase) which is responsible for biosynthesis of free branched-chain amino acids: valine, leucine and isoleucine (Tan et al., 2006; Marczewska et al., 2007).

In weed control, herbicide formulation is an important determinant of its active ingredient activity by building up its physicochemical properties. Herbicide formulation determines persistence of spray solution on leaf surface before its entrance into plant tissues. It was reported previously that liquid rather than solid herbicide formulations are more efficient in weed control (Jordan et al., 1997). Current research aims at production of herbicide formulations characterized by better solution retention, droplet spreading on the leaves surface and uptake on the plant tissue which finally affects herbicide efficacy.

The aim of the present study was to evaluate the reaction of three weed species to iodosulfuron methyl sodium and to amidosulfuron mixture applied as water dispersible granules (WG) and oil dispersion (OD), under different air temperature, relative humidity and soil moisture conditions.

MATERIALS AND METHOD

Three series of pot experiments were carried out in controlled environment chambers as a completely randomised design with three replications.

Corresponding author:
Renata Kieloch
e-mail: r.kieloch@iung.wroclaw.pl
tel. +48 71 363 87 07 ext. 118

Received 9 June 2011

Anthemis arvensis L., *Galium aparine* L. and *Thlaspi arvense* L. were sown into pots filled with a mixture of sand and peat (2:1 v/v). In the soil moisture study, brown soil originated from a field in the vicinity of Wrocław was used. Suitable water and soil volume was measured out for each pot and accurately mixed afterwards, to obtain moisture levels of 30 and 60%. Directly after sowing, the pots were placed to controlled environment chambers and kept under conditions described in Table 1.

Plants were watered daily. In the soil moisture study water was added to obtain a total weight of pot that was determined at the moment of the experiment setup. Just before herbicide treatment, number of plants was reduced to 4 per pot. At the time of spraying plants of *G. aparine* reached the stage of 1–2 whorls (BBCH=11-12), whilst those of *A. arvensis* and *T. arvensis* had 2–4 leaves (BBCH=12-14).

Herbicide treatment was carried out using a laboratory sprayer fitted with a beam equipped with TeeJet XR 11003-VS flat fan nozzles. The nozzles were operated at a pressure of 200 kPa and a speed of 2,5 km h^{-1} producing a spray volume of 250 l ha^{-1}. The herbicide was applied in two formulations – as water dispersible granules (WG) and as oil dispersion (OD). Each formulation was used at the recommended dose – 3.75 g ha^{-1} of iodosulfuron methyl sodium and 15 g ha^{-1} amidosulfuron.

Reaction of particular weed species to herbicide was determined based on fresh weight reduction brought about by the herbicide. Plants were harvested three weeks after spraying and fresh weight in each pot was determined. The fresh weight values were subjected to analysis of variance, mean values were calculated, and compared by Tukey's test at a level of significance of 0.05.

RESULTS

Temperature study

Among the tested weed species, differences in biomass quantity for untreated plants were observed, irrespective of temperature level. All species produced more fresh weight under 24/12°C compared to 12/6°C, but the smallest differences were noted for A. arvensis (Table 2).

Table 1. Climate conditions for the study of individual parameters.

Type of study	Temperature	Relative humidity	Light intensity	Photoperiod
Air temperature study	24°C day/12°C night	70%	400 µmol·$m^{-2}s^{-1}$	14/10 h
	12°C day/6°C night			
Relative humidity study	20°C day/10°C night	40%		
		70%		
Soil moisture study	20°C day/10°C night	70%		

All weed species were susceptible to the herbicide, regardless of formulation and temperature level. Plants of *A. arvensis* were considerably more susceptible to the herbicide, when they grew at 24/12°C in comparison to 12/6°C, regardless of herbicide formulation. In contrast, fresh weight reduction of *G. aparine* was not related to temperature, but was markedly related to herbicide formulation. Under warmer conditions, oil dispersion reduced weed biomass with considerably higher effect than water dispersible granules. Response of *T. arvense* to herbicide was not affected by air temperature or formulation (Table 2).

Relative humidity study

The influence of relative humidity on fresh weight of weeds was similar for *A. arvensis* and *T. arvense*. Both species produced more biomass, when they were kept under high relative humidity as compared with low humidity conditions. Similar effect was not observed for *G. aparine* (Table 3).

Table 2. Fresh weight of weeds in relation to herbicide formulation and air temperature.

Herbicide formulation	Fresh weight (g)					
	A. arvensis		*G. aparine*		*T. arvense*	
	24/12°C	12/6°C	24/12°C	12/6°C	24/12°C	12/6°C
Check	5.75	4.65	8.79	5.32	4.52	2.80
WG	0.27	0.64	0.77	0.75	0.56	0.40
OD	0.14	0.72	0.38	0.41	0.21	0.25
LSD (0.05)	0.359		0.358		n.s.	

n.s. – non significant differences

Table 3. Fresh weight of weeds in relation to herbicide formulation and relative humidity.

Herbicide formulation	Fresh weight (g)					
	A. arvensis		*G. aparine*		*T. arvense*	
	40%	70%	40%	70%	40%	70%
Check	2.94	4.48	5.38	4.08	2.94	4.42
WG	0.40	0.55	1.64	0.74	0.40	0.19
OD	0.27	0.21	0.50	0.37	0.27	0.10
LSD (0.05)	0.346		0.454		n.s.	

n.s. – non significant differences

Biomass of the weed species was significantly limited using iodosulfuron methyl sodium and amidosulfuron mixture under the two relative humidity regimes. The weed species gave different reactions to herbicide, depending on herbicide formulation and investigated climate parameter. The susceptibility of *A. arvensis* and *T. arvense* to the examined herbicide was affected neither by relative humidity nor herbicide formulation. The fresh weight of *G. aparine* was considerably better limited by OD than WG formulation, at 40% relative humidity. The efficacy of WG formulation was considerably dependent on relative humidity, resulting in higher weed control at 70% (Table 3).

Soil moisture study

Similarly to the relative humidity study, fresh weight of *A. arvensis* and *T. arvense* reached comparable level and was higher for *G. aparine*. Growth of all species was greater when wetter soil was kept under plants, but the difference in biomass productivity was the most visible for *G. aparine* (Table 4).

The weed species under study responded differently to the iodosulfuron methyl sodium and amidosulfuron mixture, depending on soil moisture. *A. arvensis* was the most sensitive to the examined herbicide and its control depended on herbicide formulation as well as on soil moisture level. When plants grew in dry soil, they were more sensitive to herbicide oil dispersion, but in the wet soil responded similarly to both herbicide formulations. Taking into consideration herbicide formulation, the activity of water dispersible granules against *A. arvensis* and *G. aparine* was more related to water status than to oil dispersion, providing significantly greater efficacy under high compared to low soil moisture (Table 4).

Table 4. Fresh weight of weeds in relation to herbicide formulation and soil moisture.

Herbicide formulation	Fresh weight (g)					
	A. arvensis		*G. aparine*		*T. arvense*	
	30%	60%	30%	60%	30%	60%
Check	3.27	4.54	3.88	5.69	2.54	3.86
WG	0.99	0.55	1.40	1.01	0.42	0.37
OD	0.47	0.29	0.80	0.65	0.30	0.14
LSD (0.05)	0.287		0.383		0.216	

Biomass reduction of *G. aparine* was considerably affected by herbicide formulation and soil moisture. The weed was better controlled when both formulations were used at 60% of soil moisture. Soil moisture considerably influenced susceptibility of *G. aparine* to the herbicide, when plants were sprayed with the WG formulation, resulting in weaker fresh weight reduction under water deficit conditions. The reaction of *T. arvense* did not depend on herbicide formulation, but it was influenced by soil moisture conditions. Plants on the wet soil were more susceptible to the herbicide when it was used as oil formulation compared to water dispersible granules (Table 4).

DISCUSSION

Herbicide performance is not only derived from the chemical and physical properties of its active ingredient, but it is determined by the sum of numerous biotic and abiotic factors as well as by cultivation technology. The efficacy of a herbicide greatly depends on the rate at which its active ingredient gets into the plant's tissue, therefore conditions that are responsible for herbicide retention and penetration play an important role in its final effect. Weather conditions around the time of spraying can modify herbicide action on leaf surface by prolongation or reduction of droplet drying period i.e. spray solution evaporates faster under low than high humidity regime (Coetzer et al., 2001; Petersen and Hurle, 2001). It has been reported previously that high air temperature and relative humidity as well as higher soil moisture favour absorption and translocation of herbicides and thereby enhance its efficacy (Olson et al., 1999; Riethmuller-Haage et al., 2007). These findings partly correspond to results obtained in this study, better effect of iodosulfuron methyl sodium and amidosulfuron mixture being found when it was applied at high air temperature and humidity as well as high soil moisture conditions.

Many papers report air temperature as one of the dominant climate parameters affecting herbicide activity (Kudsk and Kristensen, 1992; Fausey and Renner, 2001). Present investigation shows that only one weed species – *A. arvensis* was considerably more sensitive to herbicide under higher temperature, whereas the two other species did not differ in their reaction to herbicide applied under various temperature conditions. These results are partly in agreement with those described in the previous paper concerning the efficacy of another sulfonylurea herbicide – the mixture of iodosulfuron methyl sodium with mesosulfuron methyl. It was reported that *Apera spica-venti* L. showed similar sensitivity to herbicide at both cold and warm conditions whereas *Alopecurus myosuroides* L. was less sensitive at lower temperatures (Kieloch and Domaradzki, 2009). Variable response of weeds to the examined herbicide was also observed for other climate parameters such as relative humidity and soil moisture. Among the tested weed species, reaction of *T. arvense* was the least related to climate conditions, probably due to its inherent susceptibility to herbicides. From a practical point of view, *T. arvense* is very easy to control using majority of herbicides, therefore it can be satisfactorily controlled even under adverse conditions. In contrast, *G. aparine* is the least sensitive to iodosulfuron methyl sodium and amidosufuron mixture and therefore its response is strongly subjected to climate conditions. Variation in the response of weed species to herbicides applied under different environmental conditions has also been reported by others (Petersen and Hurle, 2001; Johnson and Young, 2002). That variation in reaction of particular weed species to herbicide is related to specific interaction between weed species/herbicide and herbicide/climate factor. Generally, the influence of climate conditions on the efficacy of a specific herbicide is more pronounced when a weed species is less susceptible to its active ingredient.

According to the pattern described above and results obtained from this research, there is a similar relationship between the susceptibility of *G. aparine* and herbicide formulation. A visible impact of herbicide formulation, manifesting itself in a greater plant susceptibility to oil dispersion in comparison to water dispersible granules, was even stronger than the influence of water status parameters.

The OD is a new formulation that combines the advantages of solid and liquid formulations. This formulation improves retention of spray solution and its spreading on the surface of the leaves. It keeps the leaf surface moist longer than water dispersible granules, lengthening the period of the herbicide penetration, thus increasing the amount of the active ingredient that will enter the plant. Therefore its action is less dependent on air and soil water status. The use of OD formulation is especially advantageous under critical weather conditions or in the case of a relatively late application, when weeds are older and therefore less sensitive to herbicide. Water dispersible granules tend to be more affected by climate conditions, especially those that are water status-related, like air humidity and soil moisture (Kieloch and Domaradzki, 2009). The efficacy of oil dispersion herbicide has also been reported for the mixture mesosulfuron methyl sodium + iodosulfuron methyl sodium, giving better OD than WG formulation effect (Kerlen and Brink, 2006). For a change, according to results of other researchers for other sulfonylurea herbicides (Miklaszewska, 2006; Paradowski and Jakubiak, 2006), both formulations proved similar efficacy.

Results of this research indicate that the knowledge concerning the reaction of individual weed species to herbicides applied under specific environmental conditions is very useful from a practical point of view. Such information enables to choose an optimal date of herbicide treatment, in regard to weather conditions, that ensures satisfactory control of the least susceptible weeds. Similarly, it is more evident that the efficacy of a herbicide formulation should not be significantly dependent on weather conditions, especially if we intend to control a poorly sensitive weed species.

CONCLUSIONS

1. Control of *T. arvense* was not dependent on herbicide formulation, but it was affected by soil moisture, whereas *G. aparine* was strongly affected by relative humidity, soil moisture and herbicide formulation. Among the examined species, only *A. arvensis* showed a response to the herbicide that was related to temperature.
2. Efficacy of WG formulation of iodosulfuron methyl sodium and amidosulfuron mixture was more influenced by climate conditions, especially relative humidity and soil moisture. Plants of *G. aparine* and *A. arvensis* were more sensitive to OD than WG formulation, regardless of climate factor.

REFERENCES

Coetzer E., Al-Khatib K., Loughin T. M., 2001. Glufosinate efficacy, absorption and translocation in amaranth as affected by relative humidity and temperature. Weed Sci., 49(1): 8-13.

Fausey J.C., Renner K.A., 2001. Environmental effects on CGA-248757 and flumiclorac efficacy/soybean tolerance. Weed Sci., 49(5): 668-674.

Johnson B.C., Young B.G., 2002. Influence of temperature and relative humidity on the foliar activity of mesotrione. Weed Sci., 50(2): 157-161.

Jordan D.L., Burns A.B., Barnes C.J., Barnett W., Herrick J.K., 1997. Influence of adjuvants and formulation on barnyardgrass (*Echinochloa crus-galli*) control with propanil in rice (*Oryza sativa*). Weed Technol., 11: 762-766.

Kerlen D., Brink A., 2006. OD_{esi}® – Die neue innovative, Formulierungstechnologie für Sulfonylharnstoffe, dargestellt am Beispiel von ATLANTIS® OD. J. Plant Diseases Protect., Sonderheft XX, 1033-1037.

Kieloch R., Domaradzki K., 2009. The effectiveness of two formulations of the mixture iodosulfuron methylsodium + mesosulfuron methyl in *Apera spica-venti* L. and *Alopecurus myosuroides* Huds. control depending on air temperature and humidity. AFPP Annales: 387-392.

Kudsk P., Kristensen J.L., 1992. Effect of enviromental factors on herbicide performance. Proceedings of The First International Weed Control Congress, 17-21 February 1992, Melbourne, Australia, pp. 173-185.

Kudsk P., 2001. How to investigate the influence of environmental factors on herbicide performance. Brighton Crop Protection Council Conference – Weeds, 12-15 November 2001, Brighton, UK, 2: 945-504.

Marczewska K., Rola H., Sadowski J., 2007. Free amino acids as an index of weeds resistance to chlorsulfuron. Progr. Plant Protect./Post. Ochr. Rośl., 47(3): 199-205. (in Polish)

Miklaszewska K., 2006. Assessment of new foramsulphuron and iodosulphuron formulation (Maister) used in maize.

–

Progr. Plant Protect./Post. Ochr. Rośl., 46(2): 98-101. (in Polish)

Olson B.L.S., Al-Khatib K., Stahlman P., Parrish S., Moran S., 1999. Absorption and translocation of MON 37500 in wheat and other grass species. Weed Sci., 47(1): 37-40.

Paradowski A., Jakubiak S., 2006. Weed control efficacy of Atlantis OD applied as a mixture with other herbicides in winter wheat. Progr. Plant Protect./Post. Ochr. Rośl., 46(2): 196-199. (in Polish)

Petersen J., Hurle K., 2001. Influence of climatic conditions and plant physiology on glufosinate-ammonium efficacy. Weed Res., 41(1): 31-39.

Riethmuller-Haage I., Bastiaans L., Kempenaar C., Smutny V., Kropff M.J., 2007. Are pre-spraying growing conditions a major determinant of herbicide efficacy? Weed Res., 47(5): 415-424.

Tan S., Evans R., Singh B., 2006. Herbicidal inhibitors of amino acid biosynthesis and herbicide-tolerant crops. Amino Acids, 30(2): 195-204.