Influence of adjuvants and interactions between herbicides and weed species by determination of relative adjuvant-effect on herbicide dose

Einfluss von Additiven und Interaktionen zwischen Herbiziden und Unkrautarten durch Bestimmung des relativen Additiveinflusses auf die Aufwandmenge

Arne Brathuhn* and Jan Petersen

Fachhochschule Bingen, Fachbereich Life Science and Engineering, Fachrichtung Agrarwirtschaft, Berlinstr. 109, 55144 Bingen, Germany
*Korrespondierender Autor, a.brathuhn@fh-bingen.de

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Summary

When adjuvants are used as a partner for herbicides in tank-mixtures, they can have a positive influence on herbicidal efficacy in certain situations. The addition of adjuvants can contribute to an enhanced effect of the herbicide when applying the maximum registered dose or when securing weed control of reduced application rates. The influence of adjuvants depends on weather factors, the herbicide partner and the particular weed species. This study examined the influence of different herbicide-adjuvant-combinations on various weed species. The objective of the study was to clarify, if the addition of an adjuvant to a herbicide leads to comparable results within the examined weed species or if the influence of an adjuvant use varies. The determination of relative adjuvant effects allowed comparisons of the data. The influence of six herbicide-adjuvant-combinations on six weed species was evaluated in greenhouse trials. All herbicides used were from the group of ALS-inhibitors (HRAC-group B). Data of the greenhouse experiments were compared to results from field trials, which were conducted at five sites in Rhineland-Palatinate. One herbicide with and without an addition of an adjuvant was applied per site. Data of the studies reveal that the use of adjuvants results in a positive influence on herbicidal efficacy in most cases. However, strong differences in intensity as well as quality of adjuvant effects regarding the response of different weed species were observed. The efficacy of the herbicide BIATHLON® for example was improved by addition of an adjuvant for *Galium aparine* by a factor 364.56. For *Daucus carota* this factor was 2.98. Growers should necessarily take account of these differences when using adjuvants, especially when they are used to secure reduced application rates.

Keywords: Adjuvant, ALS-inhibitors, herbicide, reduced application rates, weed control

Zusammenfassung

Additive können als Mischpartner für Herbizide in bestimmten Situationen einen positiven Einfluss auf deren Wirkung ausüben. Der Einsatz von Additiven kann zu einer Wirkungsverbesserung der maximal zugelassenen Aufwandmenge führen oder zu einer Absicherung reduzierter Aufwandmengen beitragen. Der Einfluss von Additivzugaben ist abhängig von der Witterung zur Applikationszeit, dem jeweiligen Herbizid und den zu bekämpfenden Unkrautarten. Die vorliegende Arbeit untersuchte den Einfluss von unterschiedlichen Herbizid-Additiv-Kombinationen auf mehrere Unkrautspezies. Ziel der Untersuchungen war es zu klären, ob die Zugabe eines Additivs zu einem Herbizid bei den untersuchten Unkrautarten zu vergleichbaren Ergebnissen führt oder ob der Additiveinfluss zwischen den Arten variiert. Die Bestimmung eines relativen Additiveinflusses ließ Vergleiche der Ergebnisse zu. In Gewächshausversuchen wurde der Einfluss von sechs Herbizid-Additiv-Varianten auf sechs Unkrautarten überprüft. Zum Einsatz kamen Herbizide aus der Gruppe der ALS-Inhibitoren (HRAC-Gruppe B). Die im Gewächshaus ermittelten Ergebnisse wurden mit Resultaten von Feldversuchen verglichen, die an fünf Standorten in Rheinland-Pfalz durchgeführt wurden. Es wurde jeweils ein Herbizid mit und ohne Zugabe von Additiv untersucht. Die Ergebnisse der Untersuchungen zeigen, dass der Einsatz von Additiven in den meisten Fällen zu einem positiven Einfluss auf die Wirkung der Herbizide führte. Allerdings wurden starke Differenzen, sowohl in Intensität als auch Qualität, hinsichtlich der Reaktion verschiedener Unkrautarten auf eine Additivzugabe festgestellt. So konnte die Wirkung des Herbizids BIATHLON® durch die Zugabe eines Additivs bei *Galium aparine* um einen Faktor 364,56 gegenüber der Variante ohne Additiv verbessert werden, bei *Daucus carota* lag dieser Faktor bei 2,98. Diese Differenzen sollten beim Einsatz von Additiven, besonders zur Absicherung reduzierter Aufwandmengen, unbedingt berücksichtigt werden.

Stichwörter: Additive, ALS-Inhibitoren, Herbizide, reduzierte Aufwandmengen, Unkrautbekämpfung

Introduction

Adjuvants don't show a direct effect on weeds, but as a partner for herbicides in tank-mixtures they may have a positive influence on the herbicide's efficacy in certain situations. They can support the herbicide e. g. by improving the wetting on the leaf surface, facilitate the uptake of the herbicide to the plant or help to improve sticking to leaf surface (HAZEN, 2000). While some cereal herbicides from the group of ALS-inhibitors (HRAC-group B) are recommended to be used in combination with an adjuvant by the distributors or products are sold together with an adjuvant, the use of adjuvants may also have a positive impact on the efficacy of the remaining products of this mode of action (ZHANG *et al.*, 2000).

This, on the one hand, can lead to an enhanced efficacy of herbicides when applying the maximum registered dosage and thus improve the control of weed species which are usually difficult to control by ALS-inhibitors. On the other hand, the addition of adjuvants to herbicides can be used to secure reduced herbicide rates and contribute to a more economic herbicide treatment for growers (GREEN, 2000). Since growers usually are faced with populations of different weed species in one field, the knowledge of the influence of an adjuvant on all weed species in a field is essential for securing below-labeled application rates. Therefore it is important to clarify the influence of an addition of an adjuvant on different weed species. If weed-specific differences regarding the adjuvant effect within a tank-mixture occur, these differences have to be considered when planning a herbicide treatment using reduced application rates.

The objective of this study was to investigate the response of different weed species to certain herbicide-adjuvant-combinations in greenhouse trials. Analysis of ED_{90}-values and determination of relative adjuvant-effects on herbicide doses allowed the comparison of weed-specific responses to herbicide treatments. Furthermore data from different field trials was compared with results from greenhouse trials.

Material and Methods

<u>Greenhouse trials</u>

Investigations on the influence of adjuvants on different herbicides and weed species were carried out in two greenhouse trials. In total six weed species and six herbicides were part of the trials (Tab. 1). For the estimation of dose-response curves the herbicides were applied in eight different application rates. Determination of application rates was based on previously conducted greenhouse trials. The rate of the adjuvants was kept constantly over all herbicide rates. Plants were cultivated in a sieved and sterilized soil (sandy loam, pH-value ~ 6.3, organic matter content ~ 2%) in 10 cm diameter *JIFFY-SPEEDY* pots. Seeds were sown directly into the pots (*Centaurea cyanus*), pre-germinated on wet tissue (*Galium aparine*, *Veronica hederifolia*) or grown in trays with soil and then transplanted (*Daucus carota*, *Myosotis arvensis*, *Stellaria media*). The herbicide application was done at two- to four-leaf stage (BBCH 12-14) of the weeds. For every herbicide and application rate three replicates with five plants per pot were layed out. The application was done with a laboratory sprayer (SCHACHTNER, nozzle TEE JET 9502EVS, water volume 250 L/ha, pressure 2.5 bar, speed 2.5 km/ha). Plants were watered from below by flooding the tables when necessary. 21 days after application fresh weight of the single plants was determined. Dose response curves and ED_{90}-values were calculated by using SIGMA PLOT 11.0 (Systat Software Inc.) following the methods of STREIBIG (1988) and STREIBIG *et al.* (1995).

Tab. 1 Tested weed species and used herbicides and adjuvants (greenhouse).

***Tab. 1** Untersuchte Unkrautspezies und eingesetzte Herbizide und Additive (Gewächshaus).*

Year	Species	Herbicide (max. registered rate)	Dosages tested [%]*	Adjuvant
2012	CENCY	Biathlon (70 g/ha)	1.56; 3.13; 6.25; 12.5; 25; 50; 100; 200	Dash® (1.0 L/ha)
		Lexus (20 g/ha)		Trend® (0.3 L/ha)
		Concert SX (150 g/ha)	3.13; 6.25; 12.5; 25; 50; 100; 200; 500	Trend® (0.3 L/ha)
		Primus (100 mL/ha)	1.56; 3.13; 6.25; 12.5; 25; 50; 75; 100	Dash® (1.0 L/ha)
	GALAP	Primus (100 mL/ha)	1.56; 3.13; 6.25; 12.5; 25; 50; 75; 100	Dash® (1.0 L/ha)
	VERHE	Biathlon (70 g/ha)	0.78; 1.56; 3.13; 6.25; 12.5; 25; 50; 100	Dash (1.0 L/ha)
		Concert SX (150 g/ha)		Trend (0.3 L/ha)
		Lexus (20 g/ha)		Trend (0.3 L/ha)
2013	DAUCA	Biathlon (70 g/ha)	0.78; 1.56; 3.13; 6.25; 12.5; 25; 50; 100	Dash (1.0 L/ha)
		Refine Extra (60 g/ha)		Dash (1.0 L/ha)
	GALAP	Biathlon (70 g/ha)	0.78; 1.56; 3.13; 6.25; 12.5; 25; 50; 100	Dash (1.0 L/ha)
		Hoestar Super (200 g/ha)		Mero (1.0 L/ha)
	MYOAR	Biathlon (70 g/ha)	0.78; 1.56; 3.13; 6.25; 12.5; 25; 50; 100	Dash (1.0 L/ha)
		Lexus (20 g/ha)		Trend (0.3 L/ha)
		Primus (100 mL/ha)		Dash (1.0 L/ha)
		Refine Extra (60 g/ha)		Dash (1.0 L/ha)
	STEME	Biathlon (70 g/ha)	0.08; 0.78; 1.56; 3.13; 6.25; 12.5; 25; 50	Dash (1.0 L/ha)
		Lexus (20 g/ha)		Trend (0.3 L/ha)
		Primus (100 mL/ha)		Dash (1.0 L/ha)

BIATHLON®:714 g/kg tritosulfuron; CONCERT® SX:40 g/kg metsulfuron + 400 g/kg thifensulfuron); HOESTAR® SUPER: 125 g/kg amidosulfuron + 12,5 g/kg iodosulfuron; LEXUS®: 500 g/kg flupyrsulfuron; PRIMUS®:50 g/l florasulam; REFINE® EXTRA: 320 g/kg thifensulfuron + 160 g/kg tribenuron; DASH®: 345 g/l fatty acid methyl ester + 205 g/l fatty alcohol alkoxylate + 46 g/l oleic acid ; TREND® 90: 900 g/l isodecylalcohol-ethoxylate; * % of max. registered rate

Field trials

Field trials were conducted in 2012 and 2013 at five different sites in Rhineland-Palatinate (Bingen, Gaulsheim, Winzberg I + II, Wittlich). At each site, one herbicide was applied in six or four application rates, respectively. Each herbicide was applied alone and in mixture with an adjuvant (Tab. 2). The rate of the adjuvants was kept constantly at 1.0 L/ha for every herbicide and dosage. Field trials were carried out in a randomized block design. For every herbicide and application rate four replicates were set up. The plot size was 20 m^2. For the application a plot sprayer (nozzle Al 110025, water volume 200 L/ha, pressure 2.1 bar, speed 4.5 km/ha) was used. Between end of April and beginning of May 2013 the effect of the treatments was estimated at all sites by visual assessment 21 to 28 days after application. The efficacy of an herbicide treatment at a given application rate was estimated by comparison to an untreated control. Dose response curves and ED_{90}-values were calculated by using SIGMA PLOT 11.0 (Systat Software Inc.) following the methods of STREIBIG (1988) and STREIBIG *et al.* (1995). Following to an angle transformation of the estimated values of the assessments, an one-way analysis of variance was carried out by using SAS 9.3 (SAS Institute Inc.), followed by a Tukey-HSD comparison of means ($\alpha = 0.05$).

Tab. 2 Tested weed species and used herbicides and adjuvants (field trials).

***Tab. 2** Untersuchte Unkrautspezies und eingesetzte Herbizide und Additive (Feldversuche).*

Site	Culture	Date	Herbicide (max. reg. Dosage)	Dosages [%]*	Adjuvant
Bingen	WW	NAF	Biathlon® (70 g/ha)	6.25; 12.5; 25; 50; 75; 100	DASH® (1.0 L/ha)
Gaulsheim	WW	NAH	Primus® (75 mL/ha)		
Winzberg I	WG	NAF	Biathlon® 4D (70 g/ha)		
Wittlich	WW	NAF	Biathlon® (70 g/ha)		
Winzberg II	WG	NAF	Biathlon® 4D (70 g/ha)	40; 60; 80; 100	DASH® (1.0 L/ha)

BIATHLON® 4:714 g/kg Tritosulfuron + 54 g/kg Florasulam; WW – winter wheat; WG – winter barley; *% of max. registered dosage; NAH – post em. in autumn; NAF - post em. in spring

Results

Greenhouse trials

Table 3 shows the calculated ED_{90}-values of the herbicide-treatments with and without adjuvant use sorted by weed species. With the sensitivity-factor (SF), a relationship between the calculated ED_{90}-values and the maximum registered dose of the tested herbicide is established. Values below 1 indicate ED_{90}-values below the max. registered dosage, while values above 1 indicate, that the max. registered dosage was not sufficient to control a certain weed species. The column factor shows the quotient of the sensitivity-factors ($SF_{herbicide}$ / $SF_{herbicide+adjuvant}$). The analysis of the ED_{90}-values shows that, excluding one exception (*S. media*, LEXUS/LEXUS+TREND), ED_{90}-values of the herbicide-treatments with adjuvant were lower than the corresponding values without adjuvant-use. Large differences emerged regarding the intensity of the adjuvant-effect on different weed species within one herbicide-adjuvant-mixture. The highest adjuvant-effects showed up within the product BIATHLON (*G. aparine*; factor 364.56).

The largest differences between factors of weed species in total regarding the effect of an adjuvant-addition were also observed within various treatments of this product. In the 2012 trial the adjuvant improved the herbicidal efficacy on *V. hederifolia* by a factor 2.76, on *C. cyanus* by a factor 193.07. In the 2013 trial the effect of the adjuvant strongly varied again. ED_{90}-values of the species *D. carota* were reduced 2.98 times; the values of *G. aparine* were reduced 364.56 times. There were also differences occurring within LEXUS (*C. cyanus*: factor 16.50; *V. hederifolia*: factor 1.05) and PRIMUS (*G. aparine*: factor 11.75; *S. media*: factor 1.90) treatments, as well as within CONCERT SX and REFINE EXTRA treatments. However, these differences were not as strong as within the BIATHLON treatment.

Nine of 19 tested weed-herbicide-combinations revealed ED_{90}-values above the registered dose without the addition of adjuvants, while the joint application of herbicide and adjuvant resulted in ED_{90}-values below the registered dosage. In six cases, the ED_{90}-value without adjuvant-use was below the registered dosage and was enhanced by the addition of an adjuvant. Three combinations revealed an enhancing influence of an adjuvant on the herbicidal effect; however, the ED_{90}-values with adjuvant were still above the registered dose rates.

Tab. 3 ED_{90}-values (g or mL/ha) and sensitivity-factors (SF = ED_{90}/max. registered dosage) of herbicides with and without adjuvant for different weed species (greenhouse trials).

Tab. 3 *ED_{90}-Werte (g bzw.* mL/ha*) und Sensitivitätsfaktoren (SF = ED_{90}/max. zugel. Aufwandmenge) von Herbiziden mit und ohne Additiv bei unterschiedlichen Unkrautarten (Gewächshausversuche).*

Year	Species		Herbicide	Herbicide + Adjuvant	Factor
			Biathlon	Biathlon + adj.	
2012	CENCY	ED_{90}	1594.74	8.28	193.07
		SF	22.83	0.12	
2012	VERHE	ED_{90}	15.89	5.75	2.76
		SF	0.28	0.08	
2013	DAUCA	ED_{90}	1414.04	473.83	2.98
		SF	20.20	6.77	
2013	GALAP	ED_{90}	11179.82	30.67	364.56
		SF	159.71	0.44	
2013	MYOAR	ED_{90}	3262.35	13.90	234.73
		SF	46.61	0.20	
2013	STEME	ED_{90}	184.99	3.45	53.58
		SF	2.64	0.05	
			Concert SX	Concert SX + adj.	
2012	CENCY	ED_{90}	609.06	361.62	1.68
		SF	4.06	2.41	
2012	VERHE	ED_{90}	7.12	6.84	1.04
		SF	0.05	0.05	
			Hoestar Super	Hoestar Super + adj.	
2013	GALAP	ED_{90}	338.41	45.81	7.39
		SF	1.69	0.23	
			Lexus	Lexus + adj.	
2012	CENCY	ED_{90}	188.33	11.42	16.50
		SF	9.42	0.57	
2012	VERHE	ED_{90}	31.36	29.75	1.05
		SF	1.57	1.49	
2013	MYOAR	ED_{90}	33.27	19.51	1.71
		SF	1.66	0.78	
2013	STEME	ED_{90}	6.60	8.94	0.74
		SF	0.33	0.45	
			Primus	Primus + adj.	
2012	CENCY	ED_{90}	122.76	29.20	4.21
		SF	1.23	0.29	
2012	GALAP	ED_{90}	57.15	4.86	11.75
		SF	0.57	0.05	
2013	MYOAR	ED_{90}	35.14	4.96	7.08
		SF	0.35	0.05	
2013	STEME	ED_{90}	0.74	0.39	1.90
		SF	0.007	0.004	
			Refine Extra	Refine Extra + adj.	
2013	DAUCA	ED_{90}	368.01	50.07	7.35
		SF	6.13	0.83	
2013	MYOAR	ED_{90}	23.67	1.93	12.27
		SF	0.39	0.03	

Field trials

Analysis of dose-response-curves from field trials reveals that the use of adjuvants improved the effect of herbicide treatments (Tab. 4). At the trial site Bingen, the efficacy of the BIATHLON application was improved by the addition of Dash. ED_{90}-values of *G. aparine* were improved by a factor 1.56, those of *Matricaria inodora* by 1.31. At the site in Gaulsheim efficacy of the herbicide Primus was improved by Dash for *G. aparine* by a factor 1.73. The ED_{90}-values without adjuvant-use of *G. aparine* were above the authorized amount at both sites. The addition of the adjuvant led to values below that amount. Both ED_{90}-values, with and without adjuvant-addition, of *M. inodora* were below the maximum registered dose. However, the addition of the adjuvant led to a lower ED_{90}-value.

Tab. 4 ED_{90}-values (g or mL/ha) and sensitivity-factors (SF = ED_{90}/max. registered dosage) of herbicides with and without adjuvant for different weed species (field trials).

Tab. 4 *ED_{90}-Werte (g bzw. mL/ha) und Sensitivitätsfaktoren (SF = ED_{90}/max. zugel. Aufwandmenge) von Herbiziden mit und ohne Additiv bei unterschiedlichen Unkrautarten (Feldversuche).*

Year	**Species**		**Herbicide**	**Herbicide + Adjuvant**	**Factor**
			BIATHLON	BIATHLON + adj.	
Bingen	GALAP	ED_{90}	77.00	49.40	1.56
		SF	1.10	0.71	
Bingen	MATIN	ED_{90}	57.21	43.66	1.31
		SF	0.82	0.62	
			PRIMUS	PRIMUS + adj.	
Gaulsheim	GALAP	ED_{90}	104.18	60.29	1.73
		SF	1.39	0.80	

Results of the estimation of herbicidal efficacy reveal that the success of an addition of adjuvants varies between different weed species. The product Biathlon 4D was applied with and without adjuvant at the sites Winzberg I and Winzberg II. *Viola arvensis* and *Veronica* species occurred at both sites. Table 5 shows the mean values of the estimation of herbicidal efficacy of each application rate for *V. arvensis*. A positive influence of the adjuvant could be observed at both sites. At Winzberg I the improvement from the adjuvant was observed at reduced application rates ≤ 50%. At the higher rates 75% and 100% no enhancement effect from the adjuvant could be observed. Control of the weed species was given even without the adjuvant. At the site Winzberg II the use of an adjuvant led to enhanced herbicidal effects in all application rates. There was a statistically significant difference of the mean values between herbicide without and with adjuvant in the two highest rates.

An enhanced herbicidal efficacy with use of an adjuvant was also observed for *Veronica* species (Tab. 6). At the site Winzberg I efficacy mean values of treatments with adjuvant were higher as compared to the herbicides applied alone. Weed control values of the application rates 75 and 100% were significantly different. In Winzberg II weed control values achieved by the highest and lowest application rate were significantly higher with adjuvant than without. Also at 80% of the maximum registered dosage an enhanced herbicidal efficacy by the adjuvant was observed.

Tab. 5 Effect of BIATHLON 4D in different application rates with and without adjuvant on *Viola arvensis* at two sites. Small letters indicate significant differences within one application rate.

Tab. 5 *Wirkung von BIATHLON 4D in unterschiedlichen Aufwandmengen mit und ohne Additiv auf* Viola. arvensis *an zwei Standorten. Kleinbuchstaben kennzeichnen signifikante Unterschiede innerhalb einer Aufwandmenge.*

	Winzberg I			**Winzberg II**		
Species	**D. [%]***	**BIATHLON 4D**	**BIATHLON 4D + adj.**	**D. [%]**	**BIATHLON 4D**	**BIATHLON 4D + adj.**
VIOAR	6.25	36.3 b	60.0 a	--	--	--
	12.5	56.3 b	78.8 a			
	25	81.3 a	83.8 a	40	56.3 a	62.5 a
	50	88.8 b	94.5 a	60	72.5 a	77.5 a
	75	94.5 a	95.8 a	80	81.3 b	85.0 a
	100	98.0 a	98.0 a	100	86.3 b	95.0 a

* = % of max. registered dosage

Tab. 6 Effect of BIATHLON 4D in different application rates with and without adjuvant on *Veronica* sp. at two sites. Small letters indicate significant differences within one application rate.

Tab. 6 *Wirkung von BIATHLON 4D in unterschiedlichen Aufwandmengen mit und ohne Additiv auf* Veronica sp. *an zwei Standorten. Kleinbuchstaben kennzeichnen signifikante Unterschiede innerhalb einer Aufwandmenge.*

	Winzberg I			**Winzberg II**		
Species	**D. [%]***	**BIATHLON 4D**	**BIATHLON 4D + adj.**	**D. [%]**	**BIATHLON 4D**	**BIATHLON 4D + adj.**
VERSS	6.25	66.3 a	76.3 a	--	--	--
	12.5	73.8 a	77.5 a			
	25	78.8 a	82.5 a	40	61.3 b	72.5 a
	50	85.0 a	90.0 a	60	83.8 a	78.8 a
	75	87.5 b	95.8 a	80	83.8 a	87.5 a
	100	88.8 b	97.3 a	100	83.8 b	92.5 a

* = % of max. registered dosage

Tab. 7 Effect of Biathlon 4D in different application rates with and without adjuvant on *Papaver rhoeas* at two sites. Small letters indicate significant differences within one application rate.

Tab. 7 *Wirkung von Biathlon 4D in unterschiedlichen Aufwandmengen mit und ohne Additiv auf* Papaver rhoeas *an zwei Standorten. Kleinbuchstaben kennzeichnen signifikante Unterschiede innerhalb einer Aufwandmenge.*

	Wittlich			**Winzberg II**		
Species	**D. [%]***	**BIATHLON**	**BIATHLON + adj.**	**D. [%]**	**BIATHLON 4D**	**BIATHLON 4D + adj.**
PAPRH	6.25	3.8 a	0.0 a	--	--	--
	12.5	22.5 a	0.0 b			
	25	99.0 a	78.8 a	40	75.0 a	81.3 a
	50	97.5 a	86.3 b	60	93.8 a	83.8 b
	75	97.8 a	99.0 a	80	92.5 a	93.3 a
	100	99.0 a	99.5 a	100	94.5 a	96.5 a

* = % of max. registered dosage

Apart from *Viola arvensis* and *Veronica* species at Winzberg II also *Papaver rhoeas* occurred. Contrary to both other species an enhancing influence of the adjuvant-addition could not be observed (Tab. 7). The treatment without additive revealed a weed control above 90% at application rates 60% and higher, while within the treatment with adjuvant this control value was achieved only from the 80% application rates on. Comparable results were observed in Wittlich.

Effects above 95% without adjuvant were achieved at application rates of 25% and higher. With an addition of an adjuvant these effects were achieved only from 75% application rates on.

Discussion

The use of adjuvants in herbicide treatments in cereals can result in an improved herbicidal effect regarding the control of various weed species. Results from greenhouse experiments reveal that an addition of adjuvants had an enhancing impact on the efficacy of herbicides in almost all cases. Adjuvants may be used also with herbicides that are not recommended to use with an adjuvant to secure control of weed species that are difficult to control with ALS-inhibitors at the maximum registered dosage. Although the effect of an adjuvant-addition is not equal throughout all products, data from greenhouse experiments shows that there were efficacy enhancing effects in all tested products. Furthermore it was shown that the impact of an adjuvant on a certain herbicide can vary strongly regarding the tested weed species. Similar observations were made during field trials. While at one site an improved herbicidal efficacy could be observed for two species, this could not be observed for a third species. That could be traced back to the sensitivity of a species towards a certain herbicide as well as to morphological characteristics of the particular species (leaf surface, hairs etc.).

Besides clear differences in the intensity of an adjuvant-effect, also differences in the quality of influences by adjuvants were observed. The results from greenhouse trials show that in most of the cases the addition of adjuvants lead to an ED_{90}-value below the maximum registered dosage. In some combinations an improved herbicidal efficacy was observed, however the ED_{90}-value could not be reduced below the maximum registered dosage. In six of 19 tested combinations the ED_{90}-value without adjuvant was already below that point and could be improved further. These observations were also made in results from field trials. ED_{90}-values of two herbicides could be reduced below the maximum registered dose for *G. aparine* by the addition of adjuvants. For *M. inodora* the ED_{90}-value was improved, but both treatments were below the authorized amount of herbicide.

These differences in intensity and quality of the adjuvant-effect may well be relevant if adjuvants are used to secure reduced herbicide application rates. There was no general equal effect of an addition of an adjuvant to an herbicide throughout all tested weed species. Therefore it is of decisive importance for the grower to know all weed species in a field and about the interactions of adjuvant-herbicide-mixtures and the occurring weed species to secure reduced application rates. To confirm specifically case-by-case observations, more experiments with different weed-herbicide/adjuvant-combinations should be done.

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