Influence of oils and ethoxylated alkylamines on the phytotoxicity of phenmedipham to fodder radish, oil-seed rape and sugar beet

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Inhoud

Samenvatting

Bladrammenas is gevoeliger voor fenmedifam dan koolzaad. Toevoeging van hulpstoffen, zoals minerale olie, plantaardige olie en geëtoxyleerde alkylaminen versterkt de schadesymptomen. Het verschil in gevoeligheid tussen de beide plantensoorten werd echter daarbij niet veranderd. Een verhoging van de dosering van fenmedifam of het toevoegen van hulpstoffen verminderde de vorming aan droge massa van de spruiten.
Suikerbieten kunnen worden beschadigd door fenmedifam, in het bijzonder in het kiemplantstadium. Deze beschadiging kon worden versterkt door de toevoeging van een hulpstof.
Een beschadiging van de waslaag van de bladeren van koolzaad gaf een lichte versterking de fytotoxiciteit van fenmedifam. Een voorbehandeling van de grond met TCA of ethofumesaat had bij dezelfde plantensoorten in onze proeven geen invloed op de fytotoxiciteit van fenmedifam.

Summary

Raphanus sativus is more susceptible to phenmedipham than *Brassica napus*. Addition of adjuvants like mineral oil, vegetable oil and ethoxylated alkylamines intensified the phytotoxic symptoms. The difference in sensibility between the weeds was not changed. Enlarging the dose of phenmedipham or the addition of an adjuvant decreased dry mass production of the sprouts.
Sugar beet plants can be injured by phenmedipham, especially in the seed leaves stage. These injuries can be strengthened by the addition of an adjuvant. An injury of the wax layer of the leaves increased the phytotoxicity of phenmedipham for *Brassica napus* slightly. A pretreatment of the soil by TCA or ethofumesate did not improve the phytotoxicity of phenmedipham for the same plant species.

1. Introduction

In sugarbeet crops phenmedipham is used as a post-emergence herbicide for the control of broad leaved weeds. However, weed species even belonging to the same botanical family vary greatly in susceptibility (Arndt et al., 1967; Edwards, 1968). Jorritsma (1984) mentioned charlock (*Sinapis arvensis* L.) and wild radish (*Raphanus raphanistrum* L.) being more susceptible to phenmedipham than oil-seed rape (*Brassica napus* L.). These three plant species belong to the same botanical family, the Cruciferae. The leaves of charlock and wild radish are hairy, while the leaves of oil-seed rape have some detached hairs and are covered with a wax layer.

In experiments with wild chamomile (*Matricaria recutita* L.) and black nightshade (*Solanum nigrum* L.) in the seedling stage, Zandvoort (1988) demonstrated an improvement of the phytotoxicity of phenmedipham by addition of mineral oil, vegetable oil, ethoxylated alkylamines or a nonylphenolpolyglycolether. Older plants of both weeds are more tolerant to this herbicide. The different morphology of the leaves and the different structure of the leaf surface between both plant species however was of no influence. Siebert (1972) found for wild chamomile and sugar beet an improvement of the susceptibility to phenmedipham after a pre-treatment of the soil with TCA. As with TCA a soil treatment with ethofumesate inhibits the wax formation of leaves (Pfeiffer, 1969).

Beet plants are very tolerant to phenmedipham, but in the cotyledone stage, after a relatively cool period with poor sunshine followed by weather conditions with a high light-intensity in combination with high temperatures, an application of this herbicide can give rise to injuries (Arndt et al., 1970).

Injury is more severe after the addition of an oil to the herbicide solution (Martens et al., 1970). In their experiments Miller and Nalewaja (1973) observed a greater injury of sugar beets after the addition of petroleum oil to the phenmedipham solution (9.35 l/ha) than after addition of linseed or sunflower oil. Within eight weeks the foliar growth of all sugar beet plants recovered.

On account of these observations and with the aim to realise the control of weeds with low doses of the active ingredient of the herbicides, the effects of different types of adjuvants in combination with phenmedipham, on fodder radish and oil-seed rape were compared in this study. These plants were chosen because of their difference in tolerance to phenmedipham and in the morphology of the leaf surface. At the same time the possibility to eliminate the tolerance by application of a chemical compound with an inhibiting action on the wax formation was studied. To evaluate the risk of crop damage by the addition of an adjuvant to the phenmedipham solution, experiments were done with sugar beet also.

2. Methods and materials

The experiments were carried out in a glasshouse with a minimum day/night temperature of 20/14 °C. On sunny days in summer the high temperatures were tempered by a screen. On cloudy days and in wintertime the natural light was supplemented by high-pressure Hg-lamps (Philips HLRG) to a daylength of at least 15 hours.

In all the experiments the herbicide treatments were carried out with a spraying-machine for experimental purposes fitted with a spray-boom provided with three nozzles (Birchmeier Helico Saphire 1.2-2F-0.6) at a mutual distance of 32 cm. The pressure on the spray-liquid was about 200 kPa. In this way 400 dm^3/ha of a solution was sprayed.

The treated pots were arranged in a randomized block system with four replicates and were placed on rotating tables, one replicate per table. At regular times the experimental plants were judged for retardation in growth and development, necrotic spots and other injuries. The experiments were terminated by cutting off the sprouts and determining their dry weights for each pot.

2.1. Post-emergence treatment

Seeds of fodder radish (*Raphanus sativus subsp. oleiferus* (DC.)Metzg.), cv. Sereno, oil-seed rape (*Brassica napus* L.), cv. Jet Neuf and sugar beet (*Beta vulgaris* L.), cv. Monohill, were sown about 1.5 cm deep in plastic pots containing a mixture of two parts (v/v) of a humic potting soil and one part (v/v) sand, placed on a wet felty infiltration mat of synthetic fibre.

After emergence the plants were thinned to an equal number of plants per pot (7 for fodder radish and oil-seed rape, 3 for sugar beet). The plants of fodder radish and oil-seed rape were treated at the two true leaves stage and those of sugar beet at the seed leaf stage, the two to four true leaves and at the six to eight true leaves stage of development.

Phenmedipham (as Betanal, 157 g a.i./dm^3) was applied without or in combination with an adjuvant. A choice was made from the adjuvants mineral oil (as Scheering 11E), vegetable oil (rape-seed oil, refined and emulsified with 5% of the cationic compound, Armoblen VE), cationic surfactants (as Ethokem, Armoblen T 25 or Armoblen EN 557) or ammonium sulphate.

To evaluate the influence on the crop, in some experiments an application of an adjuvant alone was carried out. In some experiments with sugar beet a nonionic surfactant (Agral LN) was used as an adjuvant too.

2.2. Pre-treatment of soil

The soil was mixed with ethofumesate (200 mg a.i. per 100 kg dry soil) or TCA (625 mg a.i. per 100 kg dry soil) before sowing the seeds of fodder radish and oil-seed rape. In the two true leaves stage series of plants were sprayed with a concentration series of phenmedipham (0 - 1889 g a.i./ha). An other series of plants were grazed with sandpaper just before spraying with the same concentrations.

3. Results

3.1. Post-emergence treatment

Only in experiments where Ethokem was used alone or in combination with phenmedipham, the leaves of fodder radish, oil-seed rape and sugar beet showed necrotic spots the day after treatment. The leaves formed after spraying did not have these spots.

Fodder radish: The symptoms of phenmedipham injury were an inhibition of growth of the plants, followed by a desiccation of the leaf-margins. In one experiment increasing the dose of phenmedipham as well as addition of an adjuvant to the herbicide solution these symptoms were moderately enhanced (Table 1A). In a second experiment the symptoms were enhanced at an increase of the dose of phenmedipham, but the addition of mineral oil or vegetable oil did not lead to an intensification of the symptoms (Table 1B).
At a low dose of phenmedipham (59 g a.i./ha) the dry mass of the sprouts was already decreased (Table 1A). A higher dose hardly decreased the dry mass production. In a second experiment (Table 1B) the dry mass production decreased at an increased dose of phenmedipham.
In both experiments the addition of an adjuvant had no effect.

Oil-seed rape: In the first experiment phenmedipham did not cause injury. Except for mineral oil, addition of an adjuvant caused weak symptoms of phenmedipham injury (desiccation of the leaf-margins). The injuries of oil-seed rape were weaker than of fodder radish.
The dry masses of sprouts were not lowered at increasing dose of phenmedipham (Table 1A). In the second experiment the dry mass at a dose of 236 g or 471 g a.i./ha was lower than at a lower dose (Table 1B). In both experiments the addition of vegetable oil decreased the dry masses of the sprouts at increased dose of phenmedipham. The mean of the dry masses for vegetable oil was lower than the mean for the object without adjuvant. The addition of mineral oil was of no influence in one experiment (Table 1A) and the dry mass was decreased in the other one (Table 1B).

Table 1. Relative dry mass of sprouts of fodder radish and oil-seed rape (% of dry mass of control) after treatment with phenmedipham or phenmedipham with adjuvant. Treatments in the two true leaves stage.

Crop	Adjuvant	Phenmedipham (g/ha)					
		0	59	118	177	236	471
A. Treatment on the 12th of Februari 1986.							
		(%)	(%)	(%)	(%)	(%)	(%)
Fodder radish	None	100 (0.337 g)	70	64	58	67	
	Mineral oil (5 l/ha)		82	86	63	65	
	Vegetable oil (5 l/ha)		64	55	70	54	
	Ethokem (4 l/ha)		81	92	72	81	
	Ammonium sulphate (3 kg/ha)		55	78	65	59	
Oil-seed rape	None	100 (0.427 g)	86	92	89	93	
	Mineral oil (5 l/ha)		94	90	109	120	
	Vegetable oil (5 l/ha)		69	61	84	56	
	Ethokem (4 l/ha)		62	61	87	72	
	Ammonium sulphate (3 kg/ha)		90	82	74	97	
B. Treatment on the 23rd of April 1986							
Fodder radish	None	100 (0.796 g)	60	65	53	43	38
	Mineral oil (5 l/ha)	100 (0.826 g)	40	40	45	35	26
	Vegetable oil (5 l/ha)	100 (0.546 g)	63	68	49	50	27
Oil-seed rape	None	100 (0.829 g)	98	102	88	61	54
	Mineral oil (5 l/ha)	100 (0.767 g)	83	86	70	61	55
	Vegetable oil (5 l/ha)	100 (0.723 g)	86	69	57	48	49

Table 2. Relative dry mass of sprouts of sugar beet (% of dry mass of control) after treatment with phenmedipham or phenmedipham with adjuvant. Treatments in the seed leaves stage.

Adjuvant		Phenmedipham (g/ha)			
Type	Dose (l/ha)	0	392	785	1178
A. Treatment on the 27th of November 1986.					
		(%)	(%)	(%)	(%)
None	0	100 (110 mg)	105	86	70
Mineral oil	2.5	100 (120 mg)	91	117	72
Mineral oil	5.0	100 (160 mg)	74	65	42
Vegetable oil	2.5	100 (170 mg)	91	66	67
Vegetable oil	5.0	100 (150 mg)	59	64	46
Armoblen T 25	0.3	100 (120 mg)	92	98	90
Armoblen T 25	0.6	100 (130 mg)	92	64	70
Armoblen EN 557	0.3	100 (140 mg)	76	109	80
Armoblen EN 557	0.6	100 (120 mg)	92	84	108
B. Treatment on the 15th of June 1987.					
None	0	100 (682 mg)	75	64	33
Mineral oil	5.0	100 (743 mg)	50	40	53
Vegetable oil	5.0	100 (762 mg)	56	50	45
Armoblen T 25	0.6	100 (689 mg)	66	47	42
Armoblen EN 557	0.6	100 (505 mg)	77	64	60
Agral	4.0	100 (304 mg)	100	68	48
C. Tratment on the 10th of September 1987.					
None	0	100 (1.188 mg)	77	66	52
Mineral oil	2.5	100 (1.226 mg)	73	53	37
Mineral oil	5.0	100 (1.415 mg)	73	37	28
Vegetable oil	2.5	100 (1.536 mg)	62	31	27
Vegetable oil	5.0	100 (1.276 mg)	65	34	30
Armoblen T 25	0.3	100 (1.173 mg)	71	51	24
Armoblen T 25	0.6	100 (1.216 mg)	76	43	20
Armoblen EN 557	0.3	100 (1.333 mg)	65	34	27
Armoblen EN 557	0.6	100 (1.159 mg)	64	20	16
Agral	2.0	100 (1.333 mg)	72	45	32
Agral	4.0	100 (1.134 mg)	64	45	25

Sugar beet: In the seed leaves stage phenmedipham caused necrosis at the leaf-margins; these symptoms were more severe at increased dose of phenmedipham. In the three experiments the severity of the necrosis varied. After the treatments on the 27th of November 1986 and on the 10th of September 1987 the symptoms were weak and after treatment on the 15th of June 1987 these were much more severe. The dry masses of the sprouts in these three experiments decreased at increased dose of phenmedipham (Tables 2). The adjuvants alone had no influence on the dry mass production. The addition of an adjuvant to the phenmedipham solution enhanced the reduction of the dry masses of sprouts more than phenmedipham alone. A high dose of an adjuvant was slightly more effective than a low one (Tables 2A and 2C). There were no clear differences observed between the types of the adjuvants. In one experiment (Table 2A) mineral oil and vegetable oil were most effective.

Treatment of sugar beet in the two to four true leaves stage with phenmedipham, gave no symptoms and the dry masses of the sprouts of the plants were not influenced (Table 3). The addition of an adjuvant did not change these results.

Table 3. Relative dry mass of sprouts of sugar beet (% of dry mass of control) after treatment with phenmedipham or phenmedipham with adjuvant. Treatments in the two to four true leaves stage.

Adjuvant		Phenmedipham (g/ha)			
Type	Dose (l/ha)	0	392	785	1178
A. Treatment on the 16th of December 1986.					
		(%)	(%)	(%)	(%)
None	0	100 (575 mg)	94	90	105
Mineral oil	5.0	100 (645 mg)	89	85	81
Vegetable oil	5.0	100 (618 mg)	85	73	84
Armoblen T 25	0.6	100 (558 mg)	90	90	98
Armoblen EN 557	0.6	100 (674 mg)	98	92	82
B. Treatment on the 25th of June 1987.					
None	0	100 (1571 mg)	71	65	70
Mineral oil	5.0	100 (1510 mg)	67	77	52
Vegetable oil	5.0	100 (1661 mg)	66	56	52
Armoblen T 25	0.6	100 (1447 mg)	96	84	56
Armoblen EN 557	0.6	100 (1375 mg)	70	63	77
Agral	4.0	100 (1396 mg)	58	73	68
C. Treatment on the 21st of September 1987.					
None	0	100 (1517 mg)	105	88	104
Mineral oil	2.5	100 (1632 mg)	85	78	61
Mineral oil	5.0	100 (1666 mg)	90	77	71
Vegetable oil	2.5	100 (1484 mg)	106	93	83
Vegetable oil	5.0	100 (1651 mg)	77	79	74
Armoblen T 25	0.3	100 (1409 mg)	122	113	111
Armoblen T 25	0.6	100 (1537 mg)	87	82	81
Armoblen EN 557	0.3	100 (1506 mg)	93	91	86
Armoblen EN 557	0.6	100 (1466 mg)	87	79	80
Agral	2.0	100 (1565 mg)	96	67	63
Agral	4.0	100 (1504 mg)	95	61	57

3.2. Pre-treatment of soil

The results of a pre-treatment of the soil on the dry mass of the sprouts of oil-seed rape are given in Table 4. The leaves of oil-seed rape plants from soil pretreated by ethofumesate were dark green and did not show the typical greyish colour of the wax layer. From the results it was shown that the dose of phenmedipham and the pre-treatment were important factors. In general, the masses of the sprouts decreased at increased dose of phenmedipham. Also a pre-treatment with ethofumesate or TCA diminished the mass of the sprouts, but there was no clear additional effect to that of phenmedipham. Grazing the leaves by sandpaper slightly enhanced the effect of phenmedipham.

Table 4. Relative dry mass of sprouts of oil-seed rape (% of dry mass of control) after grazing the leaves or with and without a pretreatment of the soil. Phenmedipham treatment on the 27th of November 1986.

Phenmedipham (g/ha)	Pre-treatment			
	None	Grazing leaves	Ethofumesate	TCA
	(%)	(%)	(%)	(%)
0	100 (1.761 g)	100 (2.006 g)	100 (1.428 g)	100 (1.519 g)
29	121	89	104	114
59	105	90	88	109
118	97	87	96	96
236	93	82	77	97
471	92	58	85	88
942	71	60	77	68
1884	58	38	49	66

4. Discussion

In our experiments phenmedipham caused symptoms of visible injuries of fodder radish and decreased in dry masses production of their sprouts. These symptoms could be enhanced by the addition of an adjuvant. Oil-seed rape was less susceptible (Table 1). This was like mentioned by Jorritsma (1984). Arndt et al. (1970) mentioned already the possibilities of the occurrence of phenmedipham injuries up to the second true leaves stage of the sugar beets. Moreover Martens et al. (1970) and Miller and Nalewaja (1973) have shown the increase of the risk for an injury after addition of an oil adjuvant.

In our experiments with sugar beet the results were variable, but the risk for an injury of phenmedipham was enhanced by adjuvants in the seed leaves stage of the beets in particular (Tables 2 and 3). The by Miller and Nalewaja (1973) mentioned difference in effect between the types of oil was not confirmed.

The results in Table 4 show, that the pre-treatment of the soil with TCA did not changen the effect of phenmedipham on the dry masses of sprouts. This result was not expected on account of the observations of Siebert (1972). He found in his experiments an improvement of the phytotoxicity of phenmedipham to wild chamomile, white mustard and sugar beet after a pre-treatment of the soil with TCA. Pfeiffer (1969) mentioned a great inhibition of wax formation on the leaves by ethofumesate in a similar way as by TCA. Also, the expected improvement of the phytotoxicity of phenmedipham to oil-seed rape after the ethofumesate treatment of the soil was not observed. To find out the eventual contribution of the wax layer to the tolerance of oil-seed rape to phenmedipham, the leaves were treated mechanically. After grazing the leaves with sandpaper the effect of phenmedipham increased only slightly, so the effect of the wax layer was not clear.

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