Herbicidal control of *Vulpia myuros* (Rat's-tail fescue) in glasshouse screening tests

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Summary

Vulpia myuros (Rat's-tail fescue) is an annual grass-weed that can thrive under minimum cultivation systems. At present it is only a minor problem in the UK but in Denmark, where more herbage seed is grown, it is a more significant problem. Three pot screening experiments were conducted to find the best herbicides to control *V. myuros* pre- and post-emergence, and to see if resistance was an issue. Flufenacet and prosulfocarb were best at the pre-emergence timing while the ALS inhibiting herbicides (e.g. mesosulfuron+iodosulfuron) performed best post-emergence. Timing was important as efficacy varied with growth stage. No evolved resistance was found in any of the seed samples tested, but *V. myuros* is naturally tolerant to ACCase inhibiting herbicides, which gave consistently poor control. Consequently, good control is possible with some herbicides with ploughing a viable cultural option due to short seed persistence.

Key words: *Vulpia myuros*, Rat's-tail fescue, herbicides, pre-emergence, post-emergence, herbicide resistance

Introduction

Vulpia myuros (Rat's-tail fescue), a winter annual grass-weed species of the Poaceae family, is a minor weed problem in UK agriculture at present. In Denmark, where much more herbage seed is grown, growers have great difficulty in controlling *V. myuros* without damaging the crop. *V. myuros* has high fecundity and because of its ability to self pollinate, its fast seed maturation period and high seed germinability, can thrive under minimum cultivation systems. Although this species occurs widely in the UK, an increase in abundance recently may be due to contamination in seeds and grain, mainly with herbage seed, such as *Festuca rubra* (red fescue). No cases of evolved herbicide resistance have been reported in *V. myuros* anywhere in the world. However, resistance to paraquat has been found in populations of *Vulpia bromoides* (squirrel-tail fescue or silver-grass) in Australia (Purba *et al.*, 1993). *V. bromoides* is naturally tolerant to ACCase herbicides due to an insensitive target ACCase (Yu *et al.*, 2004), as is also the case with some closely related *Festuca* species (Stoltenberg *et al.*, 1989).

V. myuros seed only survives 2–3 years in soil (Ball *et al.*, 2008), so ploughing is a viable option to reduce infestations. Autumn stale seed beds are effective in reducing contamination when sowing a spring crop (Jensen, 2010). A series of 10 field trials in North America indicated that sequences of flufenacet followed by mesosulfuron or sulfosulfuron might be the most effective herbicides for control of this weed in cereal crops (Ball *et al.*, 2007). Therefore, studies were carried out to determine which herbicides available in Europe would achieve the best control of a range of Danish and UK populations in three pot assays.

Materials and Methods

Expt 1: Pre- vs *post-emergence treatments using one* V. myuros *population*

Twenty seeds of *Vulpia myuros* (Danish ID 153) were sown in one litre pots filled with field soil (sandy loam). The pots were placed on outdoor tables. Pre-emergence treatments were sprayed two days after sowing and post-emergence treatments applied at the two leaf stage (with eight plants per pot). Treatments included four doses of prosulfocarb (200, 400, 800 and 1600 g a.i. ha^{-1}), pendimethalin (100, 200, 400 and 800 g a.i. ha^{-1}) and flufenacet (15.6, 31.3, 62.5 and 125 g a.i. ha^{-1}) with three replicates per treatment plus untreated in a randomised block design. A few hours after pre-emergence applications 30 mL of water was applied to the soil surface of each pot to ensure a good distribution of herbicide in the soil. Fresh foliage weights were recorded 4 weeks after herbicide applications.

Expt 2: Post-emergence treatments at two timings using one V. myuros *population*

Twenty seeds of *V. myuros* (Danish ID 153, as previously used) were sown in two-litre pots filled with a potting mixture (sandy loam/sand/peat) including all necessary nutrients. The pots were placed on outdoor tables. The number of plants per pot was reduced to 10 before spraying. Herbicides were applied at two growth stages to see if plant size affected herbicide efficacy. Treatments were applied at two leaves or at six leaves + two tillers. Treatments consisted of 13 different herbicide treatments (mesosulfuron+iodosulfuron, iodosulfuron, sulfosulfuron, flupyrsulfuron, propoxycarbozone, tralkoxydim, pinoxaden, fenoxaprop, clodinafop, flufenacet, glyphosate, propyzamide, and florasulam+pyroxsulam), sprayed at three doses (see Table 2 for doses used). Recommended adjuvants were used. There were three replicates plus untreated controls in a randomised block design. Dry foliage weights were recorded 4 weeks after herbicide applications.

Expt 3: Post emergence treatments with nine V. myuros *plus one* F. rubra *population*

Nine populations of *Vulpia myuros* were included: two from UK fields (Fosters, Highfield); three supplied by Herbiseed, UK (01/07, 02/06, 03/08); three from Denmark (ID153, ID184, ID186); one extracted from a contaminated *Festuca rubra* (red fescue) UK herbage seed sample (Count). In addition *F. rubra* from this contaminated sample was also included. Ten pre-germinated seeds were sown in 9 cm pots of loam and thinned to six plants per pot prior to spraying. Plants were treated with field rates of mesosulfuron+iodosulfuron (12+2.4 g a.i. ha^{-1} , + 'biopower' adjuvant), cycloxydim (150 g a.i. ha^{-1} + mineral oil) and flufenacet (240 g a.i. ha^{-1} at the three leaf + 1st tiller emerging stage. Herbicides were applied with a laboratory sprayer delivering 190 L water ha^{-1} at 252 kPa through a single 'Teejet' flat fan 110015VK nozzle. There were five replicates plus untreated controls in a randomised block design. Pots were kept in a glasshouse and vigour scores and foliage fresh weights were recorded 4 weeks after spraying.

Results

Expt 1: Pre- vs *post-emergence herbicide treatments*

Complete control was achieved at the highest rate of all three herbicides when applied pre-emergence (Table 1). Flufenacet gave complete control at all three doses tested, as did prosulfocarb at 400 and 800g a.i. ha^{-1}. Pendimethalin was somewhat less active with level of control declining with reducing dose rate. When applied post-emergence at two leaves, efficacy dropped substantially with all three herbicides. Prosulfocarb gave very poor control post-emergence (< 20%) at all three doses. The level of control with flufenacet and pendimethalin applied post-emergence was 27–57% lower than that achieved at equivalent rates pre-emergence. Only at the highest doses tested of these two herbicides applied post-emergence did control levels reach > 80%.

Table 1. *% reduction in foliage fresh weight relative to untreated for ID 153* Vulpia myuros *population treated pre- or post-emergence with three herbicides (Expt 1)*

Herbicide	Dose (g a.i. ha^{-1})	% reduction in foliage fresh weight relative to untreated	
		Pre-emergence	Post-emergence
Pendimethalin	100	48	*
	200	75	27
	400	100	43
	800	*	83
Prosulfocarb	200	77	*
	400	100	7
	800	100	-12
	1600	*	17
Flufenacet	15.6	100	*
	31.3	100	52
	62.5	100	73
	125	*	92
		S.E. ± 6.5	S.E. ± 16.6

Expt 2: Post-emergence treatments at two timing

Results varied considerably between treatments with level of control generally increasing with dose (Table 2.). Some herbicides were more effective when applied at the two leaf compared to the six leaf growth stage, but this effect was not consistent.

The ALS inhibitor, mesosulfuron+iodosulfuron gave very good control at both growth stages, especially at the highest rate used. Control was slightly better at the six leaf stage for the two lower doses but similar at the highest rate. Propoxycarbozone also gave good control at both growth stages at the highest rate but, at the two lower rates, control was much poorer at the six leaf compared with the two leaf stage. Conversely, both sulfosulfuron and florasulam+pyroxsulam gave better control at the six leaf stage at the two highest doses. The other two ALS inhibiting herbicides, iodosulfuron and flupyrsulfuron, gave poor control (< 51%) especially when applied at the six leaf stage.

The ACCase inhibiting herbicides, clodinafop, fenoxaprop, pinoxaden and tralkoxydim, all gave consistently poor control at both growth stages. At the highest rates used, control averaged only 12% at the two leaf and 18% at the six leaf stage for these four herbicides.

Flufenacet gave moderate (60–65%) control with the highest rate at both growth stages. Level of control at equivalent rates of flufenacet was appreciably poorer in Expt 2 compared with Expt 1. Propyzamide gave moderate (77%) control with the highest rate at the two leaf stage, but control was poorer at the six leaf stage. Control was appreciably poorer at lower rates with both herbicides.

Glyphosate gave very good (>96%) levels of control with the two highest rates at both growth stages.

Table 2. *% reduction in foliage dry weight relative to untreated for ID 153 Vulpia myuros population treated with 13 herbicides at either two leaves or six leaves + two tillers (Expt 2)*

Herbicide	Dose (g a.i. ha^{-1})	% reduction in foliage dry weights	
		two leaves	six leaves + two tillers
Mesosulfuron + iodosulfuron	2.25 + 0.45	73	86
	4.5 + 0.9	85	97
	9 + 1.8	98	97
Propoxycarbozone	10.5	72	2
	21	90	40
	42	87	87
Sulfosulfuron	4.4	61	32
	8.8	46	78
	17.6	61	92
Florasulam + pyroxsulam	0.69 + 2	30	3
	1.37 + 4.1	20	70
	2.74 + 8.2	65	94
Iodosulfuron	2.5	8	-49
	5	22	-30
	10	53	-43
Flupyrsulfuron	2.5	0	-31
	5	35	-31
	10	32	10
Clodinafop	10	10	6
	20	-1	-4
	40	2	35
Fenoxaprop-P	17.25	-6	21
	34.5	-13	51
	69	-2	22
Pinoxaden	7.5	13	-10
	15	8	14
	30	25	-29
Tralkoxydim	75	10	29
	150	13	14
	300	24	44
Flufenacet	31.25	0	-13
	62.5	26	42
	125	65	60
Glyphosate	180	67	88
	360	97	96
	720	99	98
Propyzamide	125	33	-12
	250	54	23
	500	77	41
		S.E. ± 10.01	S.E. ± 13.06

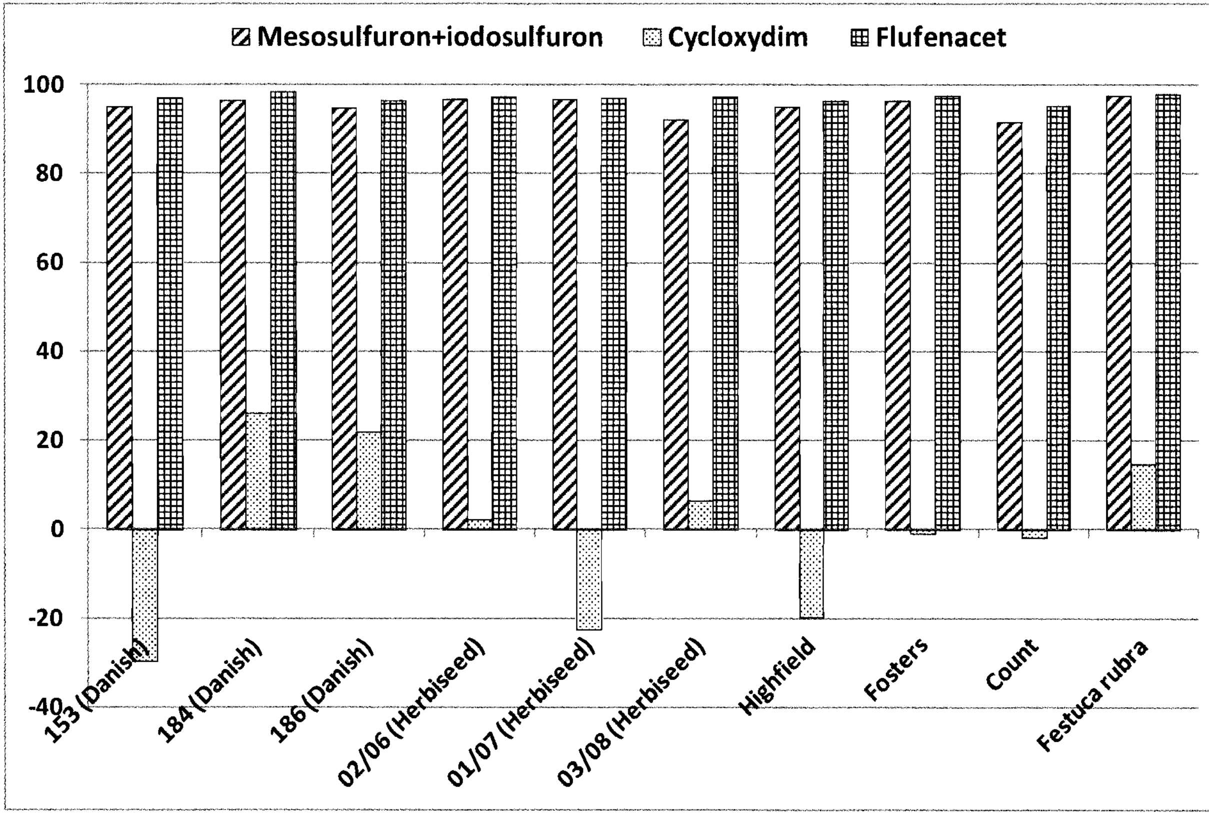

Fig. 1. The % reduction in foliage fresh weights of nine *V. myuros* and one *F. rubra* population to mesosulfuron+iodosulfuron (12 + 2.4 g a.i. ha^{-1}), cycloxydim (500 g a.i. ha^{-1}) and flufenacet (240 g a.i. ha^{-1}) applied post-emergence.

Expt 3: Post-emergence treatments with nine V. myuros *and one* F. rubra *population*

There were very substantial differences in efficacy between the three herbicides tested, but all nine *V. myuros* populations responded in a fairly consistent manner to each herbicide (Fig. 1). The *F. rubra* population also responded similarly to the *Vulpia* populations. Mesosulfuron+iodosulfuron and flufenacet gave excellent levels of control of all populations, with 92–98% and 95–98% reductions in foliage fresh weight respectively. Control of all populations with cycloxydim was very poor, with reductions in foliage fresh weight ranging from -30–26%.

Discussion

This series of experiments show that several herbicides can give effective control of *V. myuros*. Pre-emergence, flufenacet seems to be the best option, as found in North American studies, (Ball *et al.*, 2007). Prosulfocarb and pendimethalin can also give good control at high doses, but appear to be more dose dependent. Pendimethalin was also less consistent than flufenacet in the North American studies. Control options post-emergence appear slightly more limited, as these experiments confirm that *Vulpia myuros*, like *V. bromoides*, is naturally tolerant to ACCase inhibitors such as clodinafop, cycloxydim and pinoxaden. The best post-emergence options in cereals are the ALS inhibitors, with mesosulfuron+iodosulfuron giving particularly good levels of control at all doses and growth stages tested. Other ALS inhibitor, such as florasulam+pyroxsulam, propoxycarbazone and sulfosulfuron, can also give good control, but achieving the best control appears to be more dose/timing dependent than with mesosulfuron+iodosulfuron.

In oil-seed rape, propyzamide should achieve reasonable control, especially if applied to small plants. Achieving maximum control from proyzamide is vital, as ACCase herbicides are ineffective and there are few other post-emergence options. Glyphosate gave good control regardless of growth stage, so should be effective for controlling plants before drilling or in non-crop situations. Sequential applications of glyphosate were found to give effective control of *V. myuros* in field studies in North America (Jemmett *et al.*, 2008).

No evidence for evolved resistance to herbicides was found in any of the populations tested in these experiments. However, it appears that *Vulpia myuros* is naturally tolerant to ACCase herbicides due to an insensitive target site, as is also the case with *Festuca rubra* (Stoltenberg *et al.*, 1989). Yu *et al.* (2004) state that *V. bromoides* is also naturally tolerant to ALS inhibiting herbicides due to enhanced metabolism, and that these herbicides cannot be used to control *Vulpia* spp., including *V. myuros*. The results presented here, and those conducted in North America (Ball *et al.*, 2007), show clearly that these assertions are wrong. 'Natural tolerance' may occur to some specific ALS herbicides, but most certainly does not extend to all herbicides with this mode of action.

The best herbicides for the control *V. myuros* are also recommended for control of *Alopecurus myosuroides* (black-grass) so, in practice, *V. myuros* should be well controlled by the same herbicide programmes. Presently, a robust programme based around flufenacet applied pre-emergence followed by mesosulfuron+iodosulfuron is the standard for *A. myosuroides* control in the UK. Ploughing is a viable option to control high populations of *V. myuros* as the seed will only persist in the soil for 2–3 years. At present in the UK, *V. myuros* is not common as an arable weed, probably due to control with herbicides targeted for *A. myosuroides*. However *V. myuros* could become more widespread in the future as non-inversion tillage increases and the potential risk of herbicide resistance should not be ignored.

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