Long Ashton

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AFRC Institute of Arable Crops Research

Technical Report No:109

THE PRE-AND POST-EMERGENCE ACTIVITY, SELECTIVITY AND PERSISTENCE OF THE HERBICIDE FLUOROGLYCOFEN-ETHYL (RH 0265)

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THE PRE- AND POST-EMERGENCE ACTIVITY, SELECTIVITY AND PERSISTENCE OF THE HERBICIDE FLUOROGLYCOFEN-ETHYL (RH 0265)

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1. SUMMARY

In pot experiments, the herbicide fluoroglycofen-ethyl (RH 0265) at 30, 90 and 270 g a.i.ha^{-1}, was tested for pre- and post-emergence activity and selectivity on up to 19 temperate crop and 26 temperate weed species. Soil persistence of fluoroglycofen-ethyl was assessed over a 34-week period.

Generally, pre-emergence treatments of fluoroglycofen-ethyl caused less damage to dicotyledonous crop and weed species compared with the equivalent doses applied post-emergence. Monocotyledonous crops and weeds were virtually unaffected by all fluoroglycofen-ethyl treatments.

The cereals, dwarf bean, pea and sunflower showed good tolerance to pre-emergence treatments of fluoroglycofen-ethyl at 270 g a.i.ha^{-1} and perennial ryegrass, onion and carrot showed tolerance to 90 g a.i.ha^{-1}. Brassica crops, sugar beet, field bean and lettuce were unaffected by 30 g a.i.ha^{-1}. A few important broad-leaved weeds including Veronica persica were sensitive at the lowest dose and several others including Viola arvensis and Chenopodium album at the highest dose. Galium aparine and Stellaria media were unaffected by 270 g a.i.ha^{-1}.

Good tolerance to post-emergence treatments was shown by cereals, perennial ryegrass, onion and carrot at doses which several notable annual broad-leaved weeds, including Galium aparine, Veronica persica and Matricaria perforata, were sensitive. Stellaria media and the perennial broad-leaved species were particularly tolerant.

Soil persistence of active fluoroglycofen-ethyl residues, assessed by bioassay using sugar beet and Veronica persica as test species, was found to be short when compared with standard treatments of cyanazine (short persistence) and simazine (long persistence).

2. INTRODUCTION

The pre- and post-emergence activity and selectivity of new herbicides are investigated by LARS Crop and Environmental Sciences Department on a range of temperate crop and weed species, grown in pots, to indicate possible uses and potential problems. Persistence in the soil is also assessed and provides data which, in conjunction with data on crop susceptibilities, are useful in considering subsequent cropping of treated land. Although in these investigations,only one crop variety or source of weed species is used, and in one soil type, at one depth of sowing, the results provide guidelines for more detailed studies where warranted.

Fluoroglycofen-ethyl is a new herbicidal active ingredient discovered and developed by the Rohm and Haas Company. The original information from this company (in 1988) suggested that fluoroglycofen-ethyl had potential for post-emergence, and at higher doses pre-emergence, control of broad-leaved weeds, especially Galium, Viola and Veronica spp. in cereals, peanuts, soyabeans and rice at doses from 30 to 90 g a.i.ha^{-1}. Later information on the activity of fluoroglycofen-ethyl, Maigrot et al (1989), further indicated its potential in European countries as a post-emergence treatment for use in cereals against some important broad-leaved weeds.

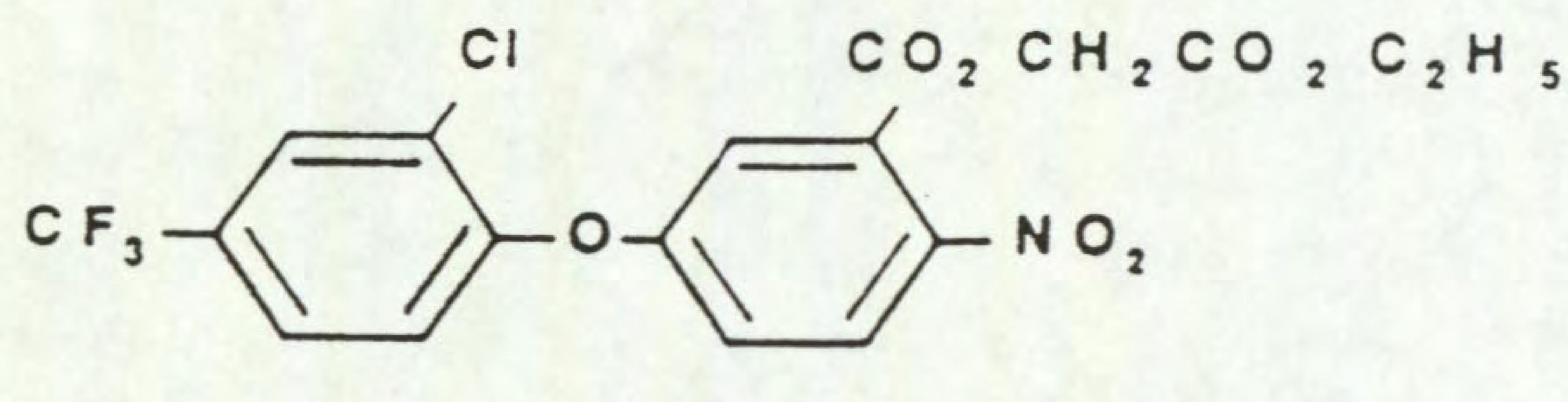
This report gives information on the pre- and post-emergence activity and selectivity of fluoroglycofen-ethyl in temperate species, and its potential for soil persistence.

3. MATERIALS AND METHODS

3.1 Herbicide details

Source:	Rohm and Haas (UK) Ltd., Lennig House, 2 Mason's Avenue, Croydon, Surrey CR9 3NB
Code number:	RH 0265
Common name:	Fluoroglycofen-ethyl
Trade names:	COMPETE
Chemical name: (IUPAC)	ethyl *O*-[5-(2-chloro-α,α,α-trifluro-*p*-tolyoxy)-2-nitrobenzoyl] glycolate

Chemical structure:



Formulation used:	5% w/w a.i. wettable powder
Doses applied:	Selectivity and persistence experiments:- 30, 90 and 270 g a.i. ha^{-1}

3.2 Pre-emergence selectivity experiment

For each species, seeds, rhizomes or roots were planted prior to spraying in 9 cm diameter plastic pots containing a Mendip sandy clay loam (Table 1) with Vitax Q4 fertiliser added at 3.3 g $litre^{-1}$. Numbers of seeds per pot, depths of sowing and seed sources are described in Appendix 1.

To improve germination, Chenopodium album seeds were kept in a 0.1M potassium nitrate solution for 48 h in the light before sowing. Cirsium arvense root fragments were soaked in thiram (0.55 g $litre^{-1}$) for one hour to protect them from soil-borne pathogens. The brassica crops and Veronica persica were given a soil drench with Cheshunt compound (ammonium carbamate + copper sulphate), at 3.05 g $litre^{-1}$, one week after spraying to prevent damping-off disease.

The herbicide was applied as a pre-emergence surface spray using a laboratory track sprayer. This was fitted with an 80015E Lurmark flat fan Evenspray nozzle delivering

340 litres ha^{-1} at a pressure of 210 kPa (30 psi) and moving at 0.5 m sec^{-1}, 30 cm above the stationary pots. There were two replicates for each treatment. After spraying, pots were set out in two randomised blocks per species in a heated glasshouse (Table 2) where normal daylight was supplemented by mercury vapour lamps to provide 14 h photoperiods. Irrigation was by overhead hand watering.

3.3 Post-emergence selectivity experiment

Plants were grown outside in 9 cm plastic pots containing Mendip loam plus fertiliser (as described in 3.2). Sowing dates were staggered so that the majority of species would reach a pre-determined growth stage (2-4 leaves) by the time of spraying. Before spraying, each species was thinned to the same number per pot. Plant numbers and growth are recorded in Appendix 2.

The herbicide was applied using a laboratory track sprayer fitted with an 80015 Lurmark kemetal flat fan nozzle delivering 335 litres ha^{-1} at a pressure of 210 kPa (30 psi) and moving at 0.5 m sec^{-1}, 45 cm above the target area of the plants. After spraying, plants were protected from rainfall for 24 h and then put outside in two randomised blocks per species. Watering was by natural rainfall plus additional overhead hand watering as necessary. Outside temperatures for the duration of the experiment are summarised in Table 2.

3.4 Assessments

Assessments were made five to six weeks after spraying pre-emergence, and three to four weeks after spraying post-emergence. Survivors were counted and scored for vigour on a 0-7 scale as follows:

0 = completely dead
1 = moribund, but not all tissue dead
2 = alive, with some green tissue, but unlikely to make much further growth
3 = very, stunted, but apparently still making some growth
4 = considerable inhibition of growth
6 = some detectable adverse effect as compared with untreated - colour differences, morphological abnormality, epinasty or slight reduction in growth
7 = indistinguishable from untreated control

Histograms of data are presented for each treatment on each species, showing both plant survival and plant vigour, calculated as percentages of untreated controls. Observed selectivities, determined using the criteria specified, are presented in Tables 3 and 4, along with comments highlighting important results.

3.5 Soil persistence

From the results of the pre-emergence selectivity experiment, sugar beet (a sensitive crop) and Veronica persica (a particularly sensitive weed) were selected as test species to determine the period for which residues of fluoroglycofen-ethyl remain active in the soil.

Residual phytotoxicity was assessed by bioassay at six dates after spraying. Fluoroglycofen-ethyl at 30, 90 and 270 g a.i.ha^{-1} was applied as a surface spray to pots (9 cm diameter) containing Mendip loam plus fertiliser (as in 3.2). "Standard" treatments of cyanazine (short persistence) at 1000 g a.i.ha^{-1} and simazine (long persistence) at 1000 g a.i.ha^{-1} were included for comparison. Pots were kept in a temperate glasshouse where night-time temperatures were not allowed to fall below 10°C and ventilation occurred during daytime above 15°C. Pots were watered from overhead as required to keep the soil moist.

For each bioassay six replicate pots of each treatment were selected. Three were sown with sugar beet (8 seeds pot^{-1}, 1 cm deep) and three with Veronica persica (20 seeds pot^{-1}, 0.25 cm deep). Plants were harvested at a pre-determined growth stage of the untreated controls, the number and fresh weight of shoots being recorded. Bioassays commenced within a day of spraying and were repeated at six to eight week intervals for 34 weeks after treatment. Residual phytotoxicity was considered to be negligible when plant numbers and shoot fresh weights exceeded 85% of the untreated control plants. Results are presented graphically in Fig. 7 (shoot weights only) and comments are made in the text.

3.6 Soil analysis and environment conditions

Table 1. Soil analysis

Mendip sandy clay loam		
Particle size analysis		%
Coarse sand	(600 μm - 2 mm)	2.1
Medium sand	(212 μm - 600 μm)	41.4
Fine sand	(63 μm - 212 μm)	13.8
Silt	(2 μm - 63 μm)	26.6
Clay	(<2 μm)	16.1
Organic matter (%)		4.6
pH (in water 1 : 2 soil : water ratio)		6.0

Table 2. Soil and environment conditions

	Type of experiment	
	Pre-emergence selectivity	Post-emergence selectivity
Dates of spraying	7 Dec 1988	11 Aug 1988 & 16 Aug 1988
Main assessment completed	17 Jan 1989	9 Sep 1988
	Temperature (°C)	
	Glasshouse	Outside
Mean	16	15
Maximum	25	28
Minimum	10	6
	Relative humidity (%)	
Mean	62	-
Maximum	86	-
Minimum	25	-

4. RESULTS

4.1 Symptoms of fluoroglycofen-ethyl damage to plants

When applied pre-emergence, fluoroglycofen-ethyl did not stop germination but inhibited growth of susceptible broad-leaved species before or soon after emergence through the soil surface. At low doses, or on less susceptible broad-leaved species, symptoms appeared as suppression of growth with interveinal chlorosis or necrotic patches on leaves, often with curling or looping of cotyledons. Some species also showed abnormal crinkling and pitting of true leaf lamina which was often associated with a darkening of this tissue.

When applied post-emergence the susceptible broad-leaved species showed a rapid leaf scorch followed by necrosis, inhibition of growing points then collapse and death of plants. On the less susceptible broad-leaved species fluoroglycofen-ethyl caused initial scorch and necrosis of leaves and inhibition of main growing points but recovery was often initiated through new growth of axillary shoots from older leaf axils.

Generally, symptoms are similar to those produced by other diphenyl ether herbicides, e.g. oxyfluorfen and acifluorfen.

4.2 Pre-emergence selectivity (Table 3 and Figures 1-3)

Matricaria perforata, Solanum nigrum and Veronica persica were susceptible to fluoroglycofen-ethyl at 30 g a.i.ha^{-1} and Sinapis arvensis and Papaver rhoeas were susceptible to 90 g a.i.ha^{-1}. Some other broad-leaved weeds, including Lamium purpureum, Chenopodium album and Viola arvensis, were suppressed at 90 g a.iha^{-1} but adequately controlled only at 270 g a.i.ha^{-1}. The broad-leaved weeds showing tolerance to fluoroglycofen-ethyl at 270 g a.i.ha^{-1} were the annual species Galium aparine, Geranium dissectum, Stellaria media and the perennial species Cirsium arvense and Convolvulus arvensis. The graminaceous weeds were unaffected by fluoroglycofen-ethyl at 90 g a.i.ha^{-1} but some damage occurred at 270 g a.i.ha^{-1}, especially to Poa trivialis which showed poor emergence and appreciable growth suppression.

Barley, oat, maize, dwarf bean, pea and sunflower were tolerant of pre-emergence applications of fluoroglycofen-ethyl at 270 g a.i.ha^{-1}, while wheat, perennial ryegrass, onion and carrot were unaffected by 90 g a.i.ha^{-1}. The brassica crops, sugar beet, field bean and lettuce were tolerant to 30 g a.i.ha^{-1} but white clover was slightly affected at this dose.

Table 3 Crop tolerance and weed sensitivity to pre-emergence treatments of Fluoroglycofen-ethyl (RH 0265)

Dose (g a.i.ha^{-1})	Tolerant crops (plant number or vigour reduced by less than 15%)	Sensitive weeds (plant number or vigour reduced by 70% or more)
270	Barley Oat Maize Dwarf bean Pea Sunflower	Chenopodium album Lamium purpureum Viola arvensis Rumex obtusifolius (plus species listed below)
90	(species listed above plus) Wheat Perennial ryegrass Onion Carrot	Sinapis arvensis Papaver rhoeas (plus species listed below)
30	(species listed above plus) Sugar beet Oilseed rape Kale Swede Field bean Lettuce	Matricaria perforata Veronica persica Solanum nigrum

Sensitive crops (severe damage or kill at 30 g a.i.ha^{-1})	Tolerant weeds (no or only slight to moderate effects at 270 g a.i.ha^{-1})
None	Galium aparine Geranium dissectum Stellaria media Cirsium arvense Convolvulus arvensis Graminaceous weeds

Figure 1 PRE-EMERGENCE SELECTIVITY EXPERIMENT

Fluoroglycofen-ethyl (RH 0265)

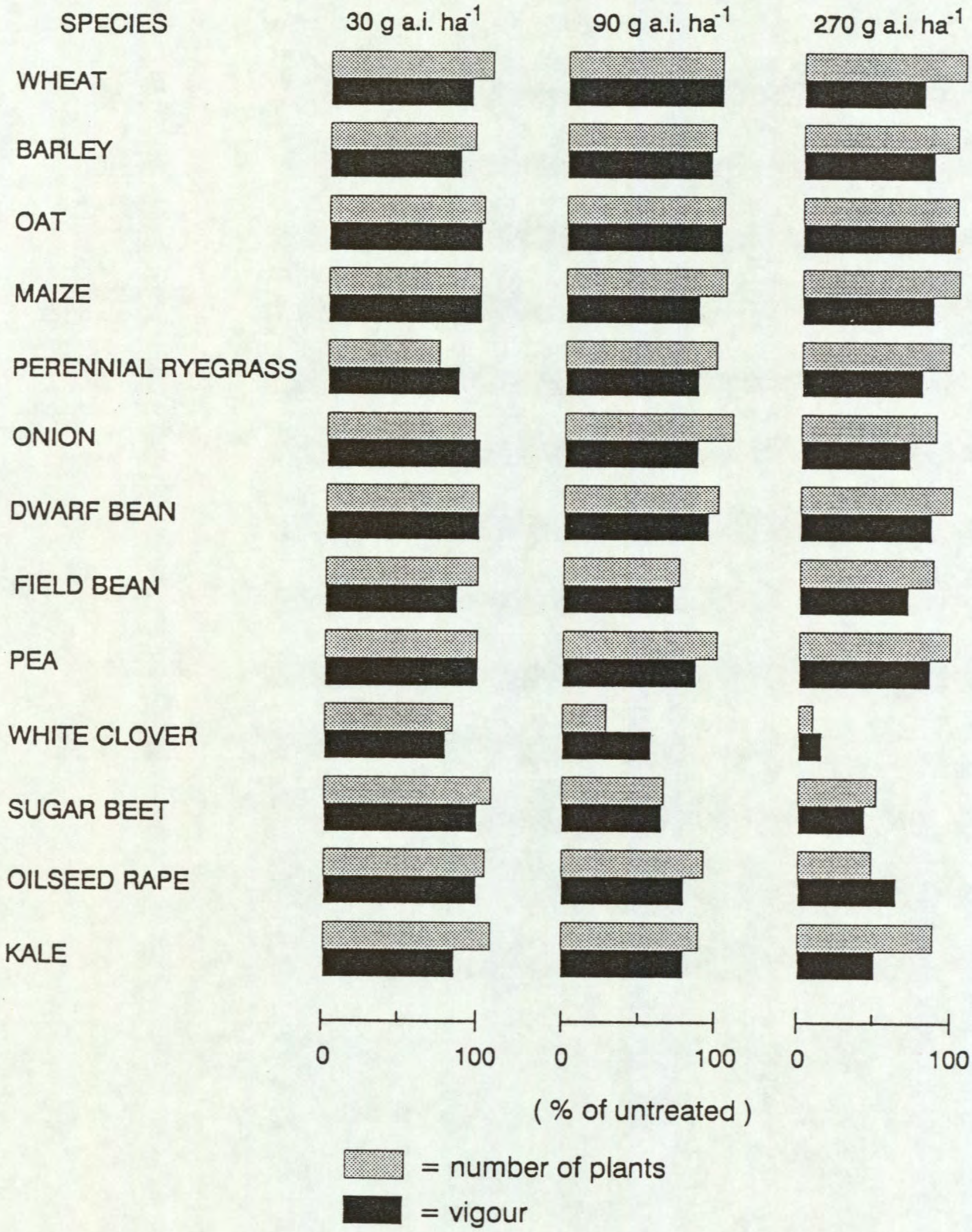


Figure 2 PRE-EMERGENCE SELECTIVITY EXPERIMENT

Fluoroglycofen-ethyl (RH 0265)

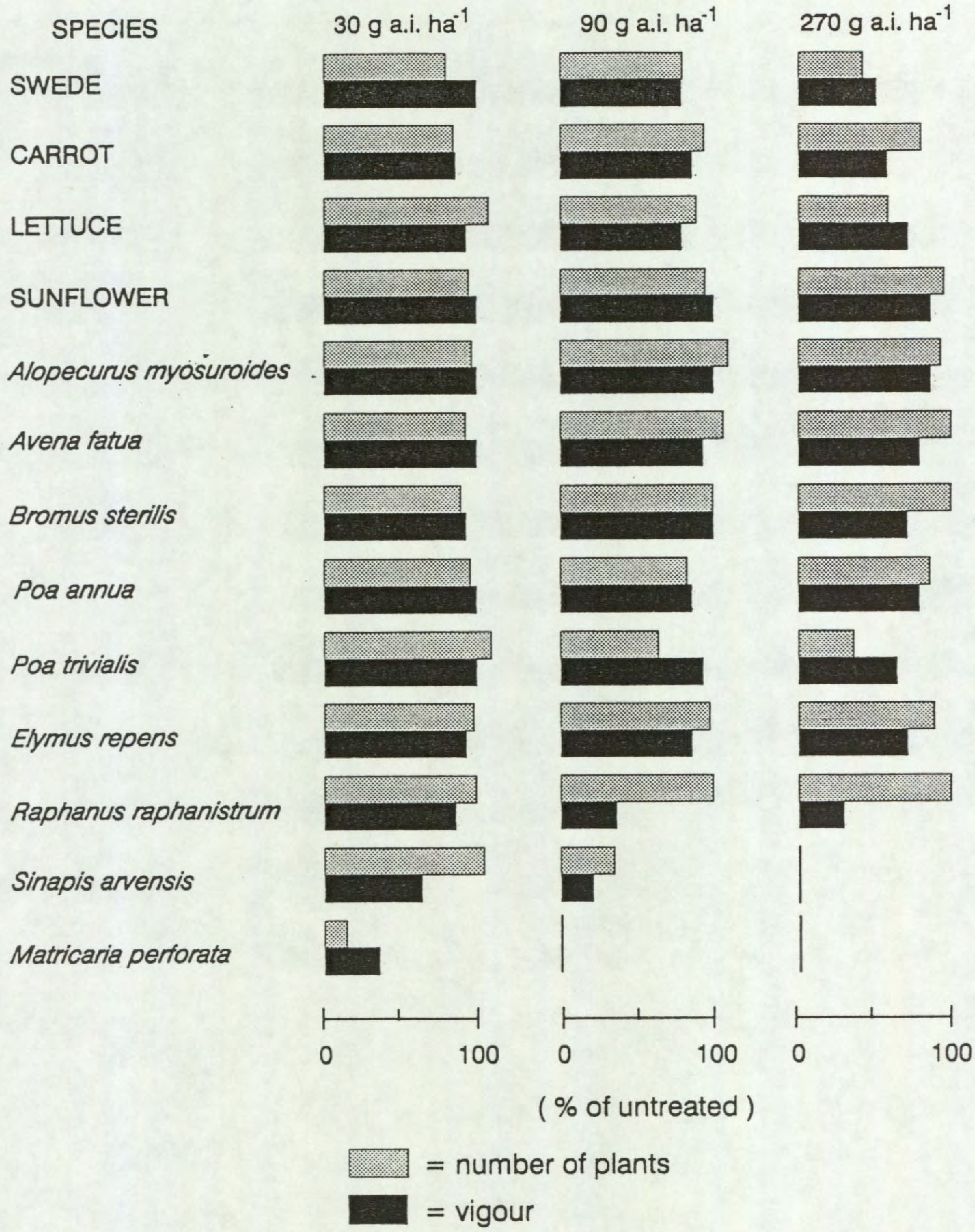
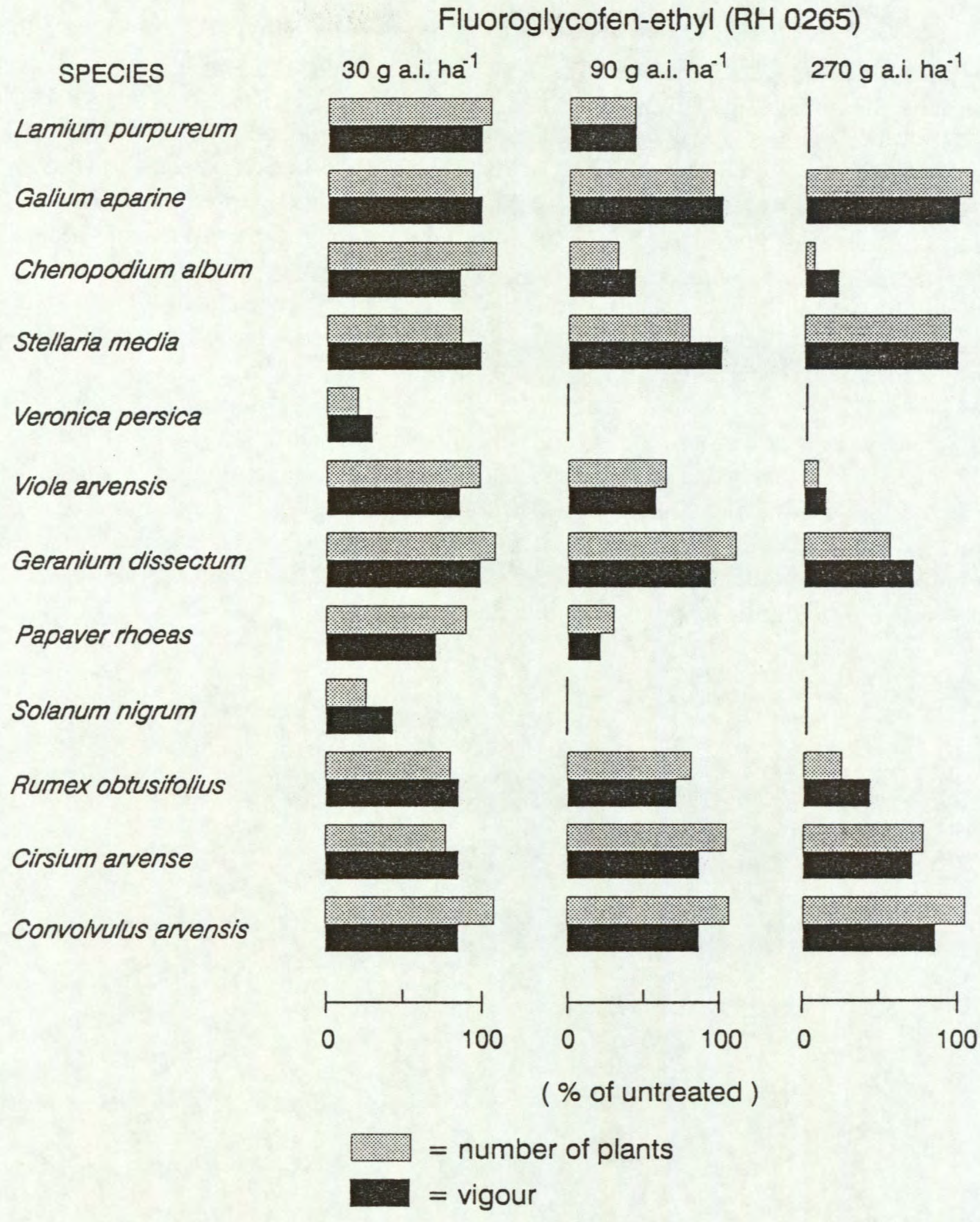


Figure 3 PRE-EMERGENCE SELECTIVITY EXPERIMENT



4.3 Post-emergence selectivity

Several broad-leaved weeds were sensitive to fluoroglycofen-ethyl at 30 g a.i.ha^{-1}; these were Galium aparine, Veronica persica, Lamium purpureum, Sinapis arvensis, Senecio vulgaris, Solanum nigrum and Spergula arvensis. Matricaria perforata was killed at 90 g a.i.ha^{-1}. Viola arvensis, although considerably suppressed at 30 and 90 g a.i.ha^{-1}, was effectively controlled only at 270 g a.i.ha^{-1}. The broad-leaved weeds showing particular tolerance to post-emergence treatments of fluoroglycofen-ethyl were Stellaria media, Chenopodium album, Geranium dissectum and the perennial species Rumex obtusifolius, Cirsium arvense and Convolvulus arvensis. Other weed species that were suppressed but not adequately controlled were Papaver rhoeas and Polygonum lapathifolium. All the graminaceous weeds tested were virtually unaffected by fluoroglycofen-ethyl at 270 g a.i.ha^{-1}.

Oat, perennial ryegrass and onion showed excellent tolerance to fluoroglycofen-ethyl at 270 g a.i.ha^{-1}, whereas wheat, barley and maize were slightly affected at this dose but unaffected by 90 g a.i.ha^{-1}. Carrot was also tolerant at 90 g a.i.ha^{-1} and dwarf bean, white clover, parsnip and sunflower were unaffected by 30 g a.i.ha^{-1}. The brassica crops, sugar beet and pea were moderately damaged by 30 g a.i.ha^{-1}, while the growth of field bean and lettuce was considerably suppressed at this dose.

Table 4 Crop tolerance and weed sensitivity to post-emergence treatments of fluoroglycofen-ethyl (RH 0265)

Dose ($g\ a.i.ha^{-1}$)	Tolerant crops (plant number or vigour reduced by less than 15%)	Sensitive weeds (plant number or vigour reduced by 70% or more)
270	Oat Perennial ryegrass Onion	Viola arvensis (plus species listed below)
90	(species listed above plus) Wheat Barley Maize Carrot	Matricaria perforata (plus species listed below)
30	(species listed above plus) Dwarf bean White clover Parsnip Sunflower	Sinapis arvensis Senecio vulgaris Lamium purpureum Galium aparine Spergula arvensis Veronica persica Solanum nigrum
Sensitive crops (severe damage or kill at 30 $g\ a.i.ha^{-1}$) Field bean Lettuce		Tolerant weeds (no or only slight to moderate effects at 270 $g\ a.i.ha^{-1}$) Chenopodium album Geranium dissectum Stellaria media Rumex obtusifolius Cirsium arvensis Convolvulus arvensis Graminaceous weeds

Figure 4 POST-EMERGENCE SELECTIVITY EXPERIMENT

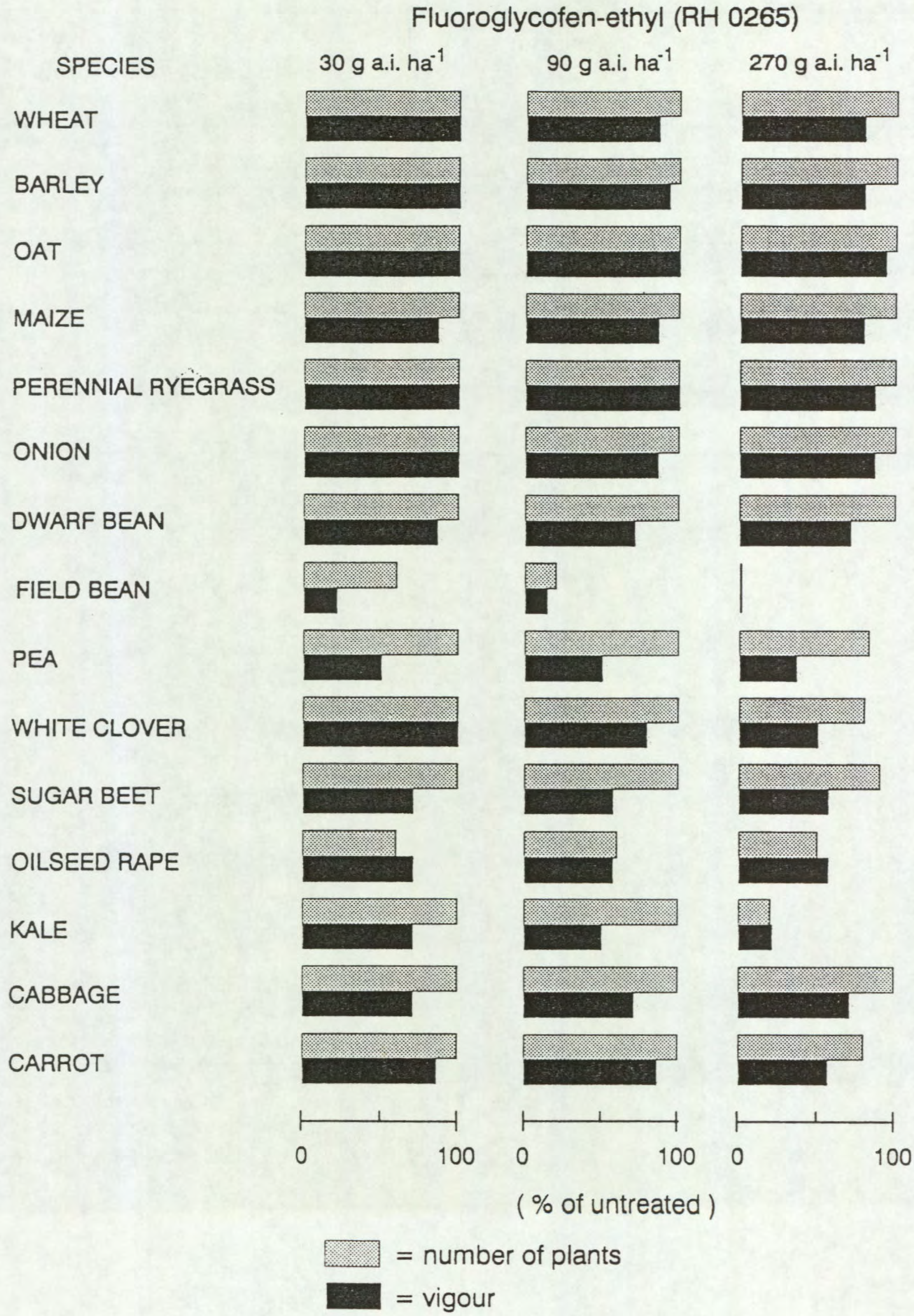


Figure 5 POST-EMERGENCE SELECTIVITY EXPERIMENT

Fluoroglycofen-ethyl (RH 0265)

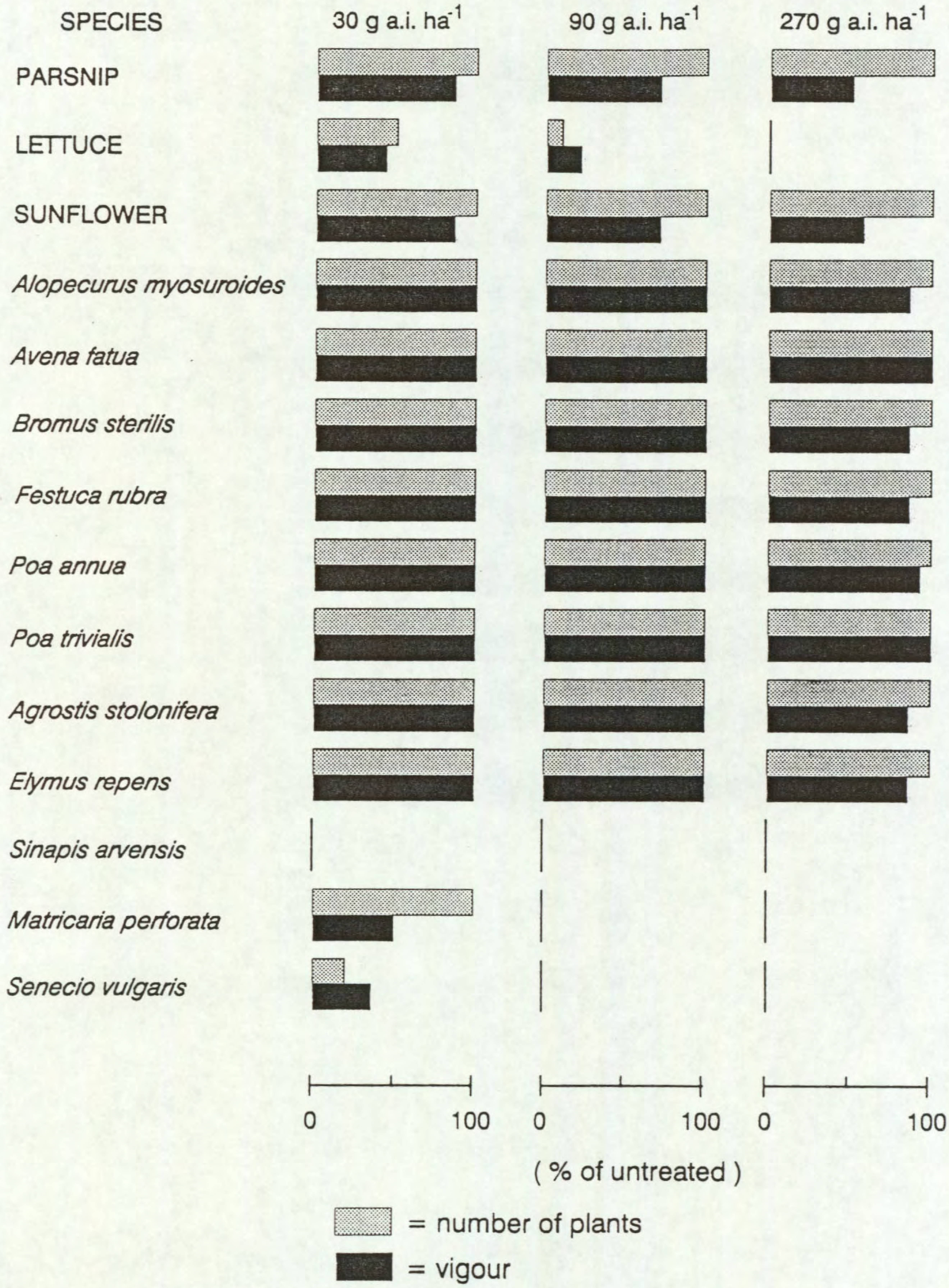
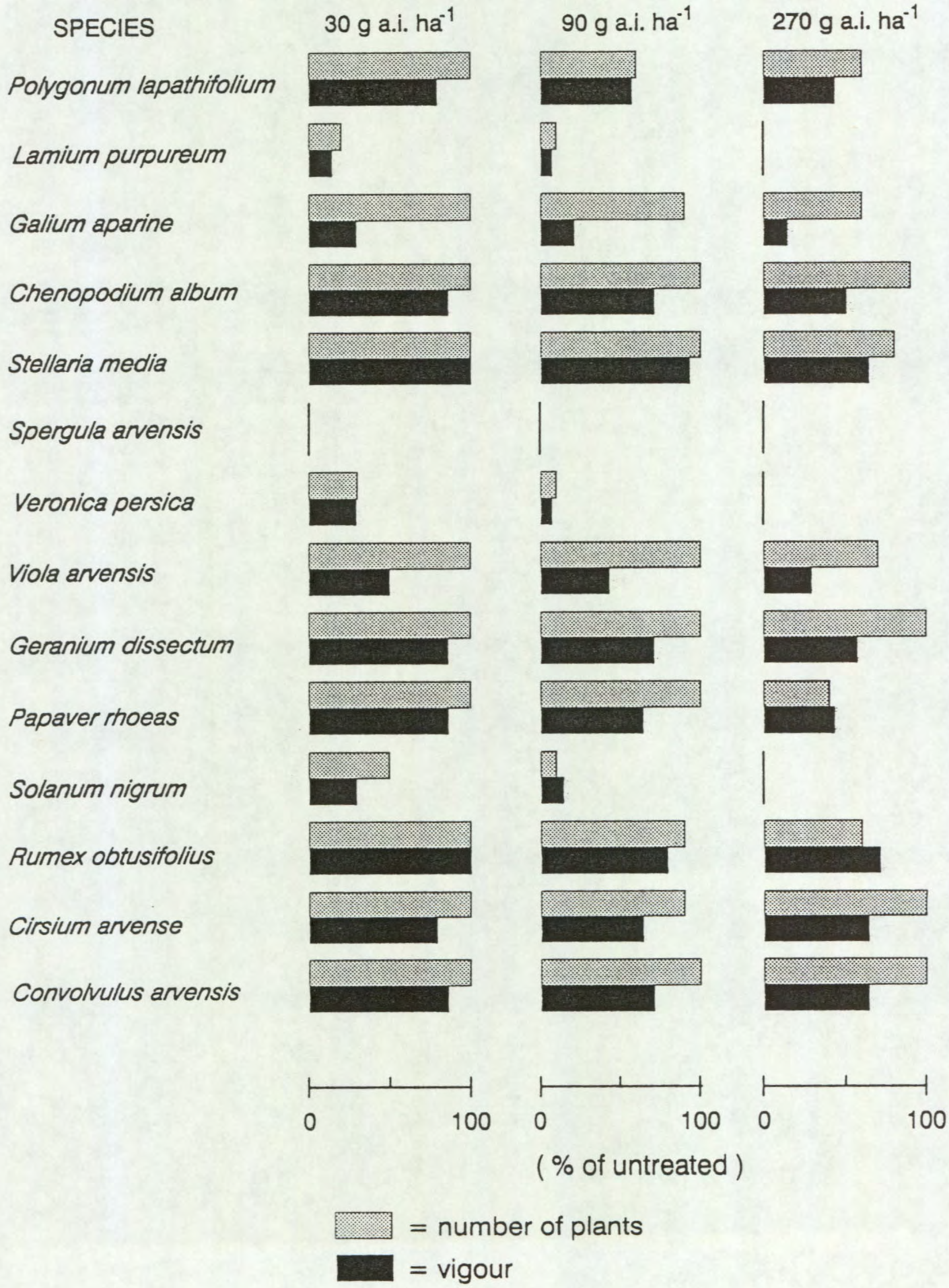


Figure 6 POST-EMERGENCE SELECTIVITY EXPERIMENT

Fluoroglycofen-ethyl (RH 0265)



4.4 Soil persistence (Fig. 7)

Test species sugar beet

Sugar beet was considerably damaged when sown into treated soil 24 h after spraying with fluoroglycofen-ethyl at 270 g a.i.ha^{-1} and moderately damaged at 30 or 90 g a.i.ha^{-1}. Six weeks after spraying there were no phytotoxic effects on sugar beet sown into soil treated with fluoroglycofen-ethyl at 30 or 90 g a.i.ha^{-1}. Fourteen weeks after treatment there was no significant reduction of shoot fresh weight when sugar beet was sown into soil treated with fluoroglycofen-ethyl at 270 g a.i.ha^{-1} but there were necrotic patches and pitting of leaf lamina; this was not apparent at the 20 week bioassay.

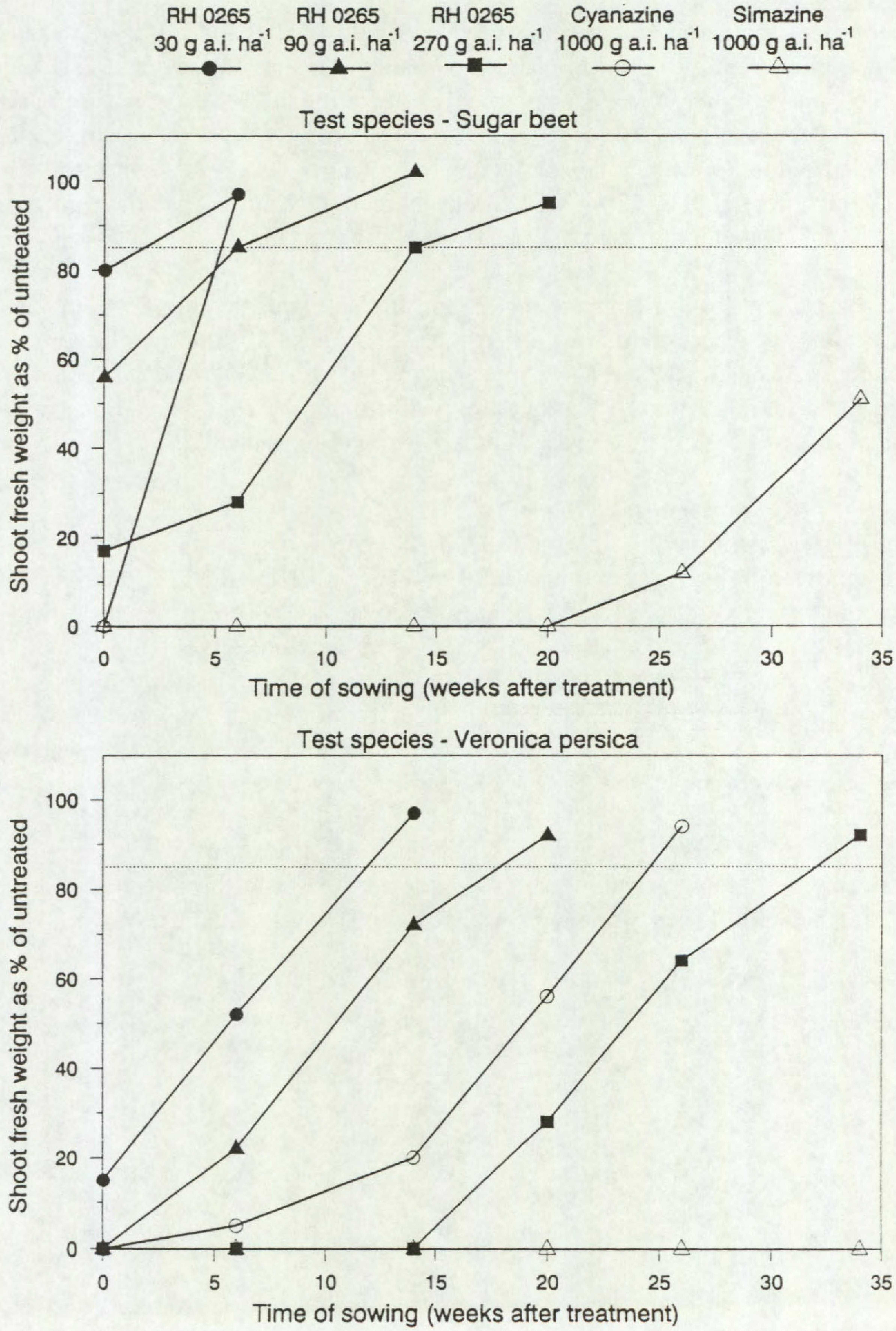
In the first bioassay, 24 h after spraying, cyanazine and simazine at 1000 g a.i.ha^{-1} caused death of sugar beet plants soon after emergence. Six weeks after spraying there were no phytotoxic effects on sugar beet sown into soil treated with cyanazine ("standard" short persistence herbicide). After 34 weeks there was still appreciable damage to sugar beet sown into soil treated with simazine ("standard" long persistence herbicide).

Test species Veronica persica

Veronica persica was severely damaged or killed when sown into treated soil 24 h after spraying with fluoroglycofen-ethyl at 30, 90 or 270 g a.i.ha^{-1}. Residual activity from fluoroglycofen-ethyl at 30 g a.i.ha^{-1} was not detectable on Veronica persica sown into treated soil 14 weeks after spraying, while activity from fluoroglycofen-ethyl at 90 g a.i.ha^{-1} was not apparent at the 20 week bioassay. Residual activity from fluoroglycofen-ethyl at 270 g a.i.ha^{-1} decreased more slowly; at the 6 and 14 week bioassays all plants were killed, activity then declined until the 34 week bioassay when no herbicide effects were apparent.

Cyanazine and simazine at 1000 g a.i.ha^{-1} initially caused death of Veronica persica plants soon after emergence. No effects from cyanazine were seen at the 26 week bioassay, whereas simazine still killed Veronica persica sown 34 weeks after treatment.

Figure 7 PERSISTENCE OF FLUOROGLYCOFEN-ETHYL (RH 0265) COMPARED WITH CYANAZINE AND SIMAZINE



5. Discussion

Fuoroglycofen-ethyl was reported by Maigrot et al (1989) to have pre-emergence activity in field trials against the dicotyledonous weed species that were affected by post-emergence treatments, but only at doses two to ten times higher than those used post-emergence. Our results confirmed that pre-emergence treatments of fluoroglycofen-ethyl cause less damage, to some dicotyledonous weeds and most of the crops tested, compared with the equivalent doses applied post-emergence. This was especially apparent with Galium aparine which was particularly sensitive to a post-emergence treatment of fluoroglycofen-ethyl at 30 g a.i.ha^{-1} but virtually unaffected by a pre-emergence treatment at 270 g a.i.ha^{-1}. Lamium purpureum, Sinapis arvensis and the dicotyledonous crops, field bean, pea and lettuce, were also considerably more sensitive to post-emergence treatments of fluoroglycofen-ethyl compared with pre-emergence treatments. However, there were exceptions where pre-emergence treatments were as effective, or more so, than the equivalent post-emergence treatments against dicotyledonous weeds. Veronica persica, Solanum nigrum and Viola arvensis were especially sensitive to fluoroglycofen-ethyl applied pre- or post-emergence while Matricaria perforata and Chenopodium album were more sensitive to pre-emergence than to post-emergence treatments.

Although fluoroglycofen-ethyl showed good activity against several intractable annual dicotyledonous weeds it lacked activity against other important weeds. It is similar to other diphenyl ether herbicides in its inability to control Stellaria media. Poor activity was also found against Geranium dissectum, perennial weeds and graminaceous weeds. Diphenyl ether herbicides are known to be active through plant shoots and roots but have limited translocation (Hance and Holly, 1990) and fluoroglycofen-ethyl appears to act in a similar manner. This explains the poor activity against perennial weeds such as Cirsium arvense and Convolvulus arvensis, and also suggests that the best time of application is when the annual weeds are young and actively growing. Consequently, if broad spectrum weed control is required, fluoroglycofen-ethyl would need to be employed as part of a sequence or in a mixture with other herbicides. Currently fluoroglycofen-ethyl is registered in Czechoslovakia for use alone in cereals, and in France for use in cereals in mixtures with isoproturon and triasulfuron for grass and broad-leaved weed control, and with mecoprop for broad-leaved weed control only (Kidd and James, 1991). A mixture of fluoroglycofen-ethyl and triasulfuron, product name "Satis" was granted UK approval in May 1992. Triasulfuron is a new sulfonylurea herbicide from Ciba Geigy previously described in this Technical Report series (West, 1988 and West, 1989).

In our investigations the period of persistence of active soil residues of fluoroglycofen-ethyl causing damage to sugar beet, at doses needed for field use, was short and similar to that of cyanazine, a known short-persistence herbicide. The sensitivity of Veronica persica to fluoroglycofen-ethyl and cyanazine was highlighted by the increased period for which it was affected by the relatively low levels of active residues remaining in the soil from these short persistence herbicides.Our results for residual activity of fluoroglycofen-ethyl suggest it would be useful in affecting later emerging sensitive weeds without risk of residual phytotoxicity problems in subsequent crops. However, as aqueous solutions of fluoroglycofen-ethyl are rapidly broken down by ultraviolet light (Maigrot et al, 1989) the persistence of active soil residues in field situations may be somewhat shorter than those in our glasshouse experiments where ultraviolet light is greatly reduced. This may also account for the poorer pre-emergence activity found in field trials (Maigrot et al, 1989), particularly against slow germinating weed species or those species with an extended period of germination.

In conclusion, the activity against certain intractable dicotyledonous weeds, low use rates and the short period of soil persistence should make fluoroglycofen-ethyl a useful post-emergence herbicide used alone or in mixtures for weed control in cereals. Furthermore, our results indicate this herbicide also has potential for use against some problem broad-leaved weeds in minor UK crops such as dwarf bean, pea, sunflower, carrot, onion and perennial ryegrass.

6. ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX 1. Species Information for Pre-emergence Experiment

Species	Cultivar or source	No. pot^{-1}	Depth of planting (cm)	Growth stage of untreated controls at assessment
Wheat (*Triticum aestivum*)	Avalon	8	1	4 leaves
Barley (*Hordeum vulgare*)	Igri	8	1	4 leaves
Oat (*Avena sativa*)	Peniarth	8	1	4 leaves
Maize (*Zea mays*)	LG 11	4	2	4-5 leaves
Perennial ryegrass (*Lolium perenne*)	Melle	12	0.5	4 leaves, 1 tiller
Onion (*Allium cepa*)	White Lisbon	15	0.5	3 leaves
Dwarf bean (*Phaseolus vulgaris*)	The Prince	3	2	2 trifoliates
Field bean (*Vicia fabia*)	Maris Bead	4	1.5	5 leaves
Pea (*Pisum sativum*)	Meteor	4	1.5	5 leaves
White clover (*Trifolium repens*)	Huia	15	0.25	5 leaves
Sugar beet (*Beta vulgaris*)	Hilma	8	1	4 leaves
Oilseed rape (*Brassica napus oleifera*)	Ariana	12	0.5	4 leaves
Kale (*Brassica oleracea acephala*)	Marrowstem	12	0.5	4 leaves
Swede (*Brassica napus*)	Marian	12	0.5	4 leaves
Carrot (*Daucus carota*)	Nandor	12	0.5	4 leaves
Lettuce (*Lactuca sativa*)	Webbs Wonderful	15	0.5	5 leaves
Sunflower (*Helianthus annuus*)	Frankasol	7	1.5	2 pairs leaves
Alopecurus myosuroides (Blackgrass)	Herbiseed	20	0.25	4 leaves, 2 tillers

APPENDIX 1. (cont'd) Species Information for Pre-emergence Experiment

Species	Cultivar or source	No. pot^{-1}	Depth of planting (cm)	Growth stage of untreated controls at assessment
Avena fatua (Wild oat)	LARS/BJW	10	1	4 leaves
Bromus sterilis (Barren brome)	Herbiseed	8	1	5 leaves, 2 tillers
Poa annua (Annual meadow-grass)	Herbiseed	20	0.25	5 leaves, 3 tillers
Poa trivialis (Rough meadow-grass)	Herbiseed	20	0.25	5 leaves, 2 tillers
Elymus repens (Common couch)	WRO	6	1.5	5 leaves
Raphanus rapanistrum (Wild radish)	Herbiseed	15	0.5	6 leaves
Sinapis arvensis (Charlock)	Herbiseed	20	0.5	6 leaves
Matricaria perforata (Scentless mayweed)	Herbiseed	25	surface	7 leaves
Lamium purpureum (Red dead-nettle)	Herbiseed	25	0.5	4 pairs leaves
Galium aparine (Cleavers)	LARS/BJW	16	0.5	4 whorls, + axillaries
Chenopodium album (Fat hen)	Herbiseed (soaked in 0.1M KNO_3 for 48 h in light)	15	0.25	8 leaves
Stellaria media (Common chickweed)	Herbiseed	20	0.25	6 leaves 4-5 branches
Veronica persica (Common field speedwell)	Herbiseed	20	0.25	4 pairs leaves, + axillaries
Viola arvensis (Field pansy)	Herbiseed	25	0.25	4 leaves
Geranium dissectum (Cut-leaved cranesbill)	Herbiseed	12	0.5	6 leaves
Papaver rhoeas (Common poppy)	Herbiseed	30	0.25	6 leaves + axillaries
Solanum nigrum (Black nightshade)	Herbiseed	20	surface	5 leaves
Rumex obtusifolius (Broad-leaved dock)	Herbiseed	15	0.25	4 leaves

APPENDIX 1. (cont'd) Species Information for Pre-emergence Experiment

Species	Cultivar or source	No. pot^{-1}	Depth of planting (cm)	Growth stage of untreated controls at assessment
Cirsium arvense (Creeping thistle)	LARS stock (roots soaked in thiram)	6	1	8 leaves
Convolvulus arvensis (Field bindweed)	Herbiseed	20	0.5	5 leaves

APPENDIX 2. Species information for Post-emergence Experiment

Species	Cultivar or source	No. plants pot^{-1}	Growth stage of untreated controls: At spraying	At assessment
Wheat (*Triticum aestivum*)	Galahad	5	2.5 leaves	7 leaves, 3 tillers
Barley (*Hordeum vulgare*)	Igri	5	2.5 leaves	6 leaves, 3 tillers
Oat (*Avena sativa*)	Peniarth	5	3 leaves	5-6 leaves, 2 tillers
Maize (*Zea mays*)	LG 11	3	2.5 leaves	7 leaves
Perennial ryegrass (*Lolium perenne*)	Melle	8	3 leaves	5 leaves, 6 tillers
Onion (*Allium cepa*)	White Lisbon	5	2.5 leaves	4 leaves
Dwarf bean (*Phaseolus vulgaris*)	The Prince	4	Unifoliates expanded	2 trifoliates
Field bean (*Vicia faba*)	Maris Bead	4	3 leaves	8 leaves
Pea (*Pisum sativum*)	Meteor	4	3 to 4 leaves	8 leaves, flower buds
White clover (*Trifolium repens*)	Huia	5	3 trifoliates	8-10 leaves
Sugar beet (*Beta vulgaris*)	Hilma	5	4 leaves	10 leaves
Oilseed rape (*Brassica oleracea oleifera*)	Ariana	5	2.5 leaves	7 leaves
Kale (*Brassica oleracea acephala*)	Marrowstem	5	2.5 leaves	5 leaves
Cabbage (*Brassica oleracea capitata*)	Golden acre	5	2.5 leaves	8 leaves
Carrot (*Daucus carota*)	Nandor	5	2 to 3 leaves	5 leaves
Lettuce (*Lactuca sativa*)	Webbs	5	3 to 4 leaves	6 leaves
Parsnip (*Pastinaca sativa*)	White gem	5	2 to 3 leaves	5 leaves
Sunflower (*Helianthus annuus*)	Frankasol	3	1.5 pairs leaves	4 pairs leaves

APPENDIX 2. (cont'd) Species information for Post-emergence Experiment

Species	Cultivar or source	No. plants pot^{-1}	Growth stage of untreated controls: At spraying	Growth stage of untreated controls: At assessment
Alopecurus myosuroides (Blackgrass)	Herbiseed	5	2 leaves 2 tillers	12 tillers
Avena fatua (Wild oat)	WRO	5	4 leaves, 1 to 2 tillers	6 leaves, 4 tillers
Bromus sterilis (Barren brome)	Herbiseed	5	3 leaves	5 leaves, 6 tillers
Festuca rubra (Red fescue)	Herbiseed	5	3 leaves, 1 tiller	12 tillers
Poa annua (Annual meadow-grass)	Herbiseed	8	3 to 4 leaves, 1 tiller	15 tillers
Poa trivialis (Rough meadow-grass)	Herbiseed	8	3 leaves, 1 tiller	16 tillers
Agrostis stolonifera (Creeping bent)	Herbiseed	5	3 leaves, 2 tillers	18 tillers
Elymus repens (Common couch)	WRO	5	3 leaves	7 leaves, 2-3 tillers
Sinapis arvensis (Charlock)	Herbiseed	5	3 leaves	5 leaves, flower buds
Matricaria perforata (Scentless mayweed)	Herbiseed	5	5 leaves	13 leaves, axillaries, flowering
Senecio vulgaris (Groundsel)	Herbiseed	5	4 leaves	15 leaves, flowering
Polygonum lapathifolium (Pale persicaria)	Herbiseed	5	3 leaves	7 leaves, flowering
Lamium purpureum (Red dead-nettle)	Herbiseed	5	2 pairs leaves	3 pairs, axillaries, flowering
Galium aparine (Cleavers)	LARS/BJW	5	2 whorls	9 whorls, axillaries
Chenopodium album (Fat hen)	Herbiseed	5	6 leaves	10 leaves, axillaries, flowering
Stellaria media (Common chickweed)	Herbiseed	5	4 pairs leaves, 2 branches	Many axillaries, flowering
Spergula arvensis (Corn spurrey)	Herbiseed	5	2 whorls	4 whorls, axillaries, flowering
Veronica persica (Common field speedwell)	Herbiseed	5	3 pairs leaves	5 pairs leaves, flowering

APPENDIX 2. (cont'd) Species information for Post-emergence Experiment

Species	Cultivar or source	No. plants pot^{-1}	Growth stage of untreated controls: At spraying	Growth stage of untreated controls: At assessment
Viola arvensis (Field pansy)	Herbiseed	5	4 leaves	9 leaves, axillaries, flowering
Geranium dissectum (Cut-leaved cranesbill)	Herbiseed	5	2.5 leaves	8 leaves
Papaver rhoeas (Common poppy)	Herbiseed	5	4 leaves	8 leaves, axillaries, flowering
Solanum nigrum (Black nightshade)	Herbiseed	5	3 leaves	8 leaves, axillaries, flowering
Rumex obtusifolius (Broad-leaved dock)	Herbiseed	5	3 leaves	5 leaves
Cirsium arvense (Creeping thistle)	LARS stock	5	3.5 leaves	8 leaves
Convolvulus arvensis (Field bindweed)	Herbiseed	5	3 to 4 leaves	8 leaves

APPENDIX 3 Addresses of UK seed suppliers

B & S Weed Seed Suppliers
Little Orchard
Main Street
Whatton in the Vale
Nottingham NG13 9EP
England

British Seedhouses
Portview Road
Avonmouth
Bristol
England

Finney Lock Seeds Ltd
Avenue Road
Witham
Essex CN18 2DX
England

Herbiseed
The Nurseries
Billingbear Park
Wokingham RG11 5RY
England

APPENDIX 4 ABBREVIATIONS

acid equivalent	a.e.	minute	min
active ingredient	a.i.	more than	$>$
approximately equal to	$\approx$	organic matter	o.m.
centimetre	cm	page	p.
cultivar (s)	cv.	pages	pp.
degree centigrade	°C	part per million	ppm
emulsifiable concentrate	EC	per	$^{-1}$
equal to	$=$	percent(age)	%
gramme	g	plus or minus	$\pm$
hectare	ha	post-emergence	post-em
hour	h	pre-emergence	pre-em
hydrogen ion concentration	pH	relative humidity	r.h.
kilogramme	kg	second	s
less than	$<$	soluble liquid	SL
litre	l.	species (singular)	sp.
maximum	max	species (plural)	spp.
metre	m	sub-species	ssp.
micrometre	μm	temperature	temp
milligramme	mg	varietas	var
millilitre	ml	volume per volume	v/v
millimetre	mm	water dispersible granule	WG
minimum	min.	wettable powder	WP

APPENDIX 5

IACR, LONG ASHTON RESEARCH STATION
CROP AND ENVIRONMENTAL SCIENCES DEPARTMENT

TECHNICAL REPORTS

(Price includes surface mail; airmail £2.00 extra)
(* denotes Reports now out of print)

6. The botany, ecology, agronomy and control of Poa trivialis L. rough-stalked meadow-grass. November 1966. G P Allen. Price £0.25

7. Flame cultivation experiments 1965. October 1966. G W Ivens - Price £0.25

8. The development of selective herbicides for kale in the United Kingdom. 2. The methylthiotriazines. Price £0.25

10. The liverwort, Marchantia polymorpha L. as a weed problem in horticulture; its extent and control. July 1968. I E Henson. Price £0.25

11. Raising plants for herbicide evaluation; a comparison of compost types. July 1968. I E Henson. Price £0.25

12.* Studies on the regeneration of perennial weeds in the glasshouse; I. Temperate species. May 1969. I E Henson. Price £0.25

13. Changes in the germination capacity of three Polygonum species following low temperature moist storage. May 1969. I E Henson. Price £0.25

14. Studies on the regeneration of perennial weeds in the glasshouse. II. Tropical species. May 1970. I E Henson. Price £0.25

15. Methods of analysis for herbicide residues. February 1977. (second edition). Price £5.75

16. Report on a joint survey of the presence of wild oat seeds in cereal seed drills in the United Kingdom during spring 1970. November 1970. J G Elliott and P J Attwood. Price £0.25

17. The pre-emergence selectivity of some newly developed herbicides, Orga 3045 (in comparison with dalapon), haloxydine (PP 493), HZ 52.112, pronamide (RH 315) and R 12001. January 1971. W G Richardson, C Parker and K Holly. Price £0.25

18. A survey from the roadside of the state of post-harvest operations in Oxfordshire in 1971. A Philipson. Price £0.25

19.* The pre-emergence selectivity of some recently developed herbicides in jute, kenaf and sesamum, and their activity against Oxalis latifolia. December 1971. M L Dean and C Parker. Price £0.25

20.* A survey of cereal husbandry and weed control in three regions of England. July 1972. A Philipson, T W Cox and J G Elliot. Price £0.35

21. An automatic punching counter. November 1972. R C Simmonds. Price £0.30

22. The pre-emergence selectivity of some newly developed herbicides: bentazon, BAS 373OH, metflurazone, SAN 9789, HER 52.123, U 27,267. December 1972. W G Richardson and M L Dean. Price £0.25

23. A survey of the presence of wild oats and blackgrass in parts of the United Kingdom during summer 1972. A Philipson. Price £0.25

24. The conduct of field experiments at the Weed Research Organization. February 1973. J G Elliott, J Holroyd and T O Robson. Price £1.25

25. The pre-emergence selectivity of some recently developed herbicides: lenacil, RU 12068, metribuzin, cyprazine, EMD-IT 5914 and benthiocarb. August 1973 W G Richardson and M L Dean. Price £1.75

26. The post-emergence selectivity of some recently developed herbicides: bentazone, EMD-IT 6412, cyprazine, metribuzin, chlornitrofen, glyphosate, MC 4379, Chlorfenprop-methyl. October 1973. W G Richardson and M L Dean. Price £3.31

27. Selectivity of benzene sulphonyl carbamate herbicides between various pasture grasses and clover. October 1973. A M Blair. Price £1.05

28. The post-emergence selectivity of eight herbicides between pasture grasses: RP 17623, HOE 701, BAS 3790, metoxuron, RU 12068, cyprazine, MC 4379, metribuzin. October 1973. A M Blair. Price £1.00

29.* The pre-emergence selectivity between pasture grasses of twelve herbicides: haloxydine, pronamide, NC 8438, Orga 3045, chlortoluron, metoxuron, dicamba, isopropalin, carbetamide, MC 4379, MBR 8251 and EMD-IT 5914. November 1973. A M Blair. Price £1.30

30. Herbicides for the control of the broad-leaved dock (Rumex obtusifolius L.). November 1973. A M Blair and J Holroyd. Price £1.06

31. Factors affecting the selectivity of six soil acting herbicides against Cyperus rotundus. February 1974. M L Dean and C Parker. Price £1.10

32. The activity and post-emergence selectivity of some recently developed herbicides: oxadizon, U-29,722, U-27,658, metflurazone, norflurazone, AC 50-191, AC 84,777 and iprymidam. June 1974. W G Richardson and M L Dean. Price £3.62

33. A permanent automatic weather station using digital integrators. September 1974. R C Simmonds. Price £0.63

34. The activity and pre-emergence selectivity of some recently developed herbicides: trifluralin, ispropalin, oryzalin, dinitramine, bifenox and perfluidone. November 1974. W G Richardson and M L Dean. Price £2.50

35. A survey of aquatic weed control methods used by Internal Drainage Boards, 1973. January 1975. T O Robson. Price £1.39

36. The activity and pre-emergence selectivity of some recently developed herbicides: Bayer 94871, tebuthiuron, AC 92553. March 1975. W G Richardson and M L Dean. Price £1.54

37. Studies on Imperata cylindrica (L.) Beauv. and Eupatorium odoratum L. October 1975. G W Ivens. Price £1.75

38. The activity and pre-emergence selectivity of some recently developed herbicides: metamitron, HOE 22870, HOE 23408, RH 2915, RP 20630. March 1976. W G Richardson, M L Dean and C Parker. Price £3.25

39. The activity and post-emergence selectivity of some recently developed herbicides: HOE 22870, HOE 23408, flamprop-methyl, metamitron and cyperquat. May 1976. W G Richardson and C Parker. Price £3.20

40. The activity and pre-emergence selectivity of some recently developed herbicides: RP 20810, oxadiazon, chloronitrofen, nitrofen, flamprop-isopropyl. August 1976. W G Richardson, M L Dean and C Parker. Price £2.75

41. The activity and pre-emergence selectivity of some recently developed herbicides: K 1441, mefluidide, WL 29226, epronaz, Dowco 290 and triclopyr. November 1976. W G Richardson and C Parker. Price £3.40

42. The activity and post-emergence selectivity of some recently developed herbicides: KUE 2079A, HOE 29152, RH 2915, triclopyr and Dowco 290. March 1977. W G Richardson and C Parker. Price £3.50

43. The activity and pre-emergence selectivity of some recently developed herbicides: dimefuron, hexazinone, trifop-methyl, fluothiuron, buthidazole and butam. November 1977. W G Richardson and C Parker. Price £3.75

44. The activity and selectivity of the herbicides: ethofumesate, RU 12709 and isoproturon. December 1977. W G Richardson, C Parker and M L Dean. Price £4.00

45. Methods of analysis for determining the effects of herbicides on soil micro-organisms and their activities. January 1978. M P Greaves, S L Cooper, H A Davies, J A P Marsh and G I Wingfield. Price £4.00

46. Pot experiments at the Weed Research Organization with forest crop and weed species. February 1978. D J Turner and W G Richardson. Price £2.70

47. Field experiments to investigate the long-term effects of repeated applications of MCPA, tri-allate, simazine and linuron - effects on the quality of barley, wheat, maize and carrots. July 1978. J D Fryer, P D Smith and J W Ludwig. Price £1.20

48. Factors affecting the toxicity of paraquat and dalapon to grass swards. March 1978. A K Oswald. Price £2.90

49. The activity and post-emergence selectivity of some recently developed herbicides: NP 48, RH 5205 and Pyridate. May 1978. W G Richardson and C Parker. Price £2.50

50. Sedge weeds of East Africa - II. Distribution. July 1978. P J Terry. Price £1.50

51. The activity and selectivity of the herbicides methabenzthiazuron, metoxuron, chlortoluron and cyanazine. September 1978. W G Richardson and C Parker. Price £2.20

52. Antidotes for the protection of field bean (Vicia faba L.) from damage by EPTC and other herbicides. February 1979. A M Blair. Price £1.35

53. Antidotes for the protection of wheat from damage by tri-allate. February 1979. A M Blair. Price £2.00

54. The activity and pre-emergence selectivity of some recently developed herbicides: alachlor, metolachlor, dimethachlor, alloxydim-sodium and fluridone. April 1979. W G Richardson and C Parker. Price £3.00

55. The activity and selectivity of the herbicides carbetamide, methazole, R 11913 and OCS 21693. May 1979. W G Richardson and C Parker. Price £1.80

56. Growing weeds from seeds and other propagules for experimental purposes. July 1979. R H Webster. Price £1.10

57. The activity and pre-emergence selectivity of some recently developed herbicides: R 40244, AC 206784, pendimethalin, butralin, acifluorfen and FMC 39821. December 1979. W G Richardson, T M West and C Parker. Price £3.55

58. The tolerance of fenugreek (Trigonella foenumgraecum L.) to various herbicides. December 1979. W G Richardson. Price £1.55

59. Recommended tests for assessing the side-effects of pesticides on the soil microflora. April 1980. M P Greaves, N J Poole, K H Domsch, G Jagnow and W Verstraete. Price £2.00 (Amended version to be printed in 1986)

60. Properties of natural rainfalls and their simulation in the laboratory for pesticide research. September 1980. R C Simmonds. Price £1.25

61. The activity and post-emergence selectivity of some recently developed herbicides: R 40244, DPX 4189, acifluorfen, ARD 34/02 (NP 55) and PP 009. November 1980. W G Richardson, T M West and C Parker. Price £3.75

62. The activity and pre emergence selectivity of some recently developed herbicides: UBI S-734, SSH-43, ARD 34/02 (NP 55), PP 009 and DPX 4189. February 1981. W G Richardson, T M West and C Parker. Price £3.50

63. The activity and post-emergence selectivity of some recently developed herbicides: SSH-41, MB 30755, AC 213087, AC 222293 and Dowco 433. May 1981. W G Richardson, T M West and C Parker. Price £3.50

64. The activity and pre-emergence selectivity of some recently developed herbicides: chlomethoxynil, NC 20484 and MBR 18337. March 1982. W G Richardson, T M West and C Parker. Price £3.00

65. A system for monitoring environmental factors in controlled environment chambers and glasshouses, June 1982. R C Simmonds. Price £1.50

66. The activity and pre emergence selectivity of some recently developed herbicides: AC 213087 and AC 222293. December 1982. W G Richardson, T M West and C Parker. Price £2.00

67. The activity and post-emergence selectivity of some recently developed herbicides: trifopsime, glufosinate, RH 8817,MBR 18337 and NC 20484. December 1982. W G Richardson, T M West and C Parker. Price £3.25

68. The activity and pre-emergence selectivity of some recently developed herbicides: WL 49818, WL 82830, WL 83627, WL 83801 and DPX 5648. December 1982. W G Richardson, T M West and C Parker. Price £4.00

69. The activity and late post-emergence selectivity of some recently developed herbicides: AC 252925, DOWCO 453, HOE 33171 and HOE 35609. March 1983. W G Richardson, T M West and G P White. Price £3.25

70. The potential of various herbicides for selective control of weed grasses and Stellaria media in newly sown ryegrass/clover leys and ryegrass seed crops. May 1983. F W kirkham. Price £1.75

71. A feasibility study of the use of chemicals for rural amenity areas. Sponsored by the Countryside Commision. September 1983. E J P Marshall. Price £5.00

72. The activity and late post-emergence selectivity of FBC 32197. November 1983. W G Richardson, T M West and G P White. Price £1.25

73. Paraquat persistence - statistical analysis of the WRO long term trial. January 1984. R J Hance, T H Byast, P D Smith and T M Weight. Price £1.00

74. The activity and post-emergence selectivity of some recently developed herbicides: AC 252214, DPX-T6376 and chlorazifop. February 1984. W G Richardson, T M West and G P White. Price £2.00

75. The effect of temperature and soil moisture on the activity of isoproturon and chlortoluron on Alopecurus myosuroides and winter wheat. May 1984. A M Blair. Price £2.00

76. A laboratory rainfall simulator for pesticide studies. May 1984. R C Simmonds. Price £2.00

77. Experiments on the effects of the herbivorous fish, grass carp (Ctenopharyngodon idella Val.) on aquatic vascular plants, algae, zooplankton and phytoplankton and the importance of water temperature on the success of weed control. September 1984. M C Fowler. Price £3.50

78. The activity and post-emergence selectivity of some recently developed herbicides: MCPA-thioethyl, MT-124, tridiphane, aclonifen and RST 20024 H. October 1984. W G Richardson and T M West. Price £5.40

79. A preliminary study on the effect of some agricultural herbicides on a range of field margin flora. November 1984. J E Birnie. Price £2.50

80. The activity and pre-emergence selectivity of some recently developed herbicides: imazaquin, isoxaben, metsulfuron-methyl, aclonifen and orbencarb. December 1984. W G Richardson and T M West. Price £6.50

81. The side effects of alloxydim sodium, sethoxydim, acifluorfen and fluazifop-butyl on legume growth and nodulation. January 1985. J M Bebb, M P Greaves and W G Richardson. Price £3.00

82. An IRGA system for continuous monitoring of CO_2 and H_2O vapour exchange in replicate plants growing in controlled environments. January 1985. C R Merritt and R C Simmonds. Price £3.00

83. A laboratory pot sprayer for use with controlled environment chambers. February 1985. R C Simmonds and J A Drinkwater. Price £2.50

84. Maps of the changes in the weeds of Boddington Barn field over twenty years (1961-1981). March 1985. R J Chancellor. Price £4.50

85. The use of bentazone and pyridyl herbicides alone and in mixtures for the control of creeping thistle (Cirsium arvense L.) in grassland. April 1985. W G Richardson, A K Oswald and T M West. Price £1.50

86. The activity and pre-emergence selectivity of some recently developed herbicides: metazachlor, butamifos, MT-124, tridiphane, MK 616 and prodiamine. May 1985. W G Richardson and T M West. Price £7.00

87. The potential use of grass growth retardants at Sullom Voe terminal, Shetland. A report prepared for W J Cairns and Partners, 16 Randolph Crescent, Edinburgh, Environmental Consultants to BP Petroleum Development Ltd as Operators of Sullom Voe Terminal. May 1985. E J P Marshall. Price £3.00

88. A further study of the effect of six cereal herbicide treatments on a range of broad-leaved field margin plants. June 1985. J E Birnie. Price £2.50

89. The activity, pre- and post-emergence selectivity of diflufenican. December 1985. W G Richardson and T M West. Price £3.00

90. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: imazaquin, AC 263499, cinmethylin and isoxaben. January 1986. C Parker and A K Wilson. Price £2.60

91. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: DOWCO 453, quizalofop-ethyl, BAS 517 00H, cinmethylin, AC 263499 and RST 20024H. W G Richardson and T M West. Price £6.20

92. The activity and post-emergence selectivity of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259 and DPX-M 6316. W G Richardson and T M West. February 1986. Price £4.20

93. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: metazachlor, RST 20024H, orbencarb and diflufenican. C Parker and A K Wilson. February 1986. Price £2.70

94. Screening strawberries for tolerance to 96 herbicides and growth regulators applied to the foliage and roots. D V Clay. February 1986. Price £5.00

95. Grass growth retardant use at Sullom Voe Terminal, Shetland 1985 Programme Report. (A report prepared for W J Cairns & Partners, 16 Randolph Crescent, Edinburgh, Environmental Consultants to BP Petroleum Development Limited as Operators of Sullom Voe Terminal). E J P Marshall. August 1986. Price £2.50

96. Studies of the flora in Arable Field Margins. E J P Marshall. October 1986. Price £3.50

97. The post-emergence selectivity in warm-climate species of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259 and DPX-M 6316. A K Wilson and C Parker. February 1987. Price £3.75

98. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259, DPX-M 6316 and FMC 57020. T M West and W G Richardson. November 1987. Price £6.00

99. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259, DPX-M 6316 and FMC 57020. A K Wilson and C Parker. August 1988. Price £5.00

100. The post-emergence selectivity in warm-climate species of some recently developed herbicides: AC 263499, BAS 514, CGA 131036, DPX L5300, and DPX A7881. A K Wilson. August 1988. Price £3.50

101. The pre-emergence selectivity in warm climate species of some recently developed herbicides: CGA 131036, DPX L5300, DPX A7881 and BAS 514. A K Wilson. August 1988. Price £3.50

102. The post-emergence selectivity in warm-climate species of two recently developed herbicides: FD 4026 (PP604) and BAS 51700H. A K Wilson. August 1988. Price £3.50

103. Assessment of amenity grass mixtures for use in low-maintenance situations. G Donaldson, G M Arnold and M Perry. February 1988. Price £6.00

104. The activity and post-emergence selectivity of some recently developed herbicides: imazethapyr, BAS 51800H, DPX-L5300, triasulfuron and DPX-A7881. T M West. June 1988. Price £6.00

105. Further assessments of amenity grass mixtures for use in low maintenance situations. G Donaldson, G M Arnold and S Cooper. March 1989. Price £6.00

106. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: BAS 51800H, DPX-L5300, triasulfuron, DPX-A7881 and fluroxypyr. T M West. November 1989. Price £6.00

107. Pre-emergence and post-emergence selectivity and persistence of the herbicide UBI C4874. T M West. August 1992. Price £4.00

108. The activity, pre-emergence and post-emergence selectivity and persistence of the herbicide SAN 582 H. T M West. January 1993. Price £4.00