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THE POTENTIAL OF VARIOUS HERBICIDES FOR SELECTIVE CONTROL OF WEED GRASSES AND STELLARIA MEDIA IN NEWLY SOWN RYEGRASS/CLOVER LEYS AND RYEGRASS SEED CROPS

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THE POTENTIAL OF VARIOUS HERBICIDES FOR SELECTIVE CONTROL OF WEED GRASSES AND STELLARIA MEDIA IN NEWLY SOWN RYEGRASS/ CLOVER LEYS AND RYEGRASS SEED CROPS

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SUMMARY

In two autumn-sown field experiments, several herbicides were sprayed either pre- or early post-emergence onto monoculture plots of perennial ryegrass (Lolium perenne L.), white clover (Trifolium repens L.), Poa annua L., Poa trivialis L., Alopecurus myosuroides Huds. and Stellaria media (L.) Vill..

Pre-emergence treatments of both metamitron and bifenox showed large margins of selectivity between ryegrass and the two Poa spp., whilst metamitron was only slightly less effective against A. myosuroides than was the standard herbicide, ethofumesate. Pre-emergence asulam controlled P. trivialis with little effect on clover and only a transient depression in ryegrass growth, but was ineffective against P. annua. White clover was very tolerant of prosulfalin but this herbicide showed only a small margin of selectivity between perennial ryegrass and the two Poa spp. Difenzoquat, applied post-emergence, was as effective as post-emergence ethofumesate against P. annua, but with both herbicides a high dose was needed to achieve adequate control. Of the herbicides tested on S. media, only ethofumesate and methabenzthiazuron controlled this species without damaging ryegrass, but methabenzthiazuron, bifenox and fluorodifen all controlled volunteer Capsella bursa-pastoris (L.) Med..

INTRODUCTION

Perennial ryegrass leys and seed crops are frequently invaded by unsown species which can affect crop production significantly. Rough meadow-grass (Poa trivialis) and black-grass (Alopecurus myosuroides) can seriously affect the profitability of grass seed production, not only by reducing yields through seedling competition but also by increasing seed cleaning costs (Evans & Yates, 1981). A survey carried out in 1977-8 showed that Poa spp. and Stellaria media were the most common weed species occurring in newly-sown leys (Haggar, 1979a). Other work has shown that the benefits of controlling these species can persist beyond the first harvest year when weed densities are high (Haggar & Kirkham, 1981).

Ethofumesate and methabenzthiazuron are both approved for the control of several grass and broad-leaved weeds (including the above species) in ryegrass leys and seed crops (Anon, 1983). However, ethofumesate is very expensive and methabenzthiazuron has proved unreliable for P. annua control (Haggar & Kirkham, 1981; Kirkham & Haggar, 1982). Both herbicides are toxic to clover and there is no clover-safe herbicide currently recommended for the control of grass weeds during sward establishment.

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* Grass and Fodder Crops Group

Table 1. Sowing and spraying details

Expt.	Sowing date	Species	Sowing rate (kg/ha)	Herbicides	Doses (kg a.i./ a.e./ha)	Formulation	Vol. rate (l/ha)	Spray date
A	19.9.78	Perennial ryegrass		ethofumesate	1.7, 3.4	e.c.	337	21.9.78
		(cv. Talbot)	22	metamitron	2.0, 4.0	w.p.	"	(pre-em)
		Poa trivialis	15	terbutryne	1.25, 2.5	w.p.	"	"
		Poa annua	15	carbetamide	0.25, 0.5	w.p.	"	"
		Alopecurus myosuroides	45*	ethofumesate	2.0, 4.0	e.c.	"	6.12.78
				difenzoquat	1.5, 3.0	w.s.p.	"	(post-em)
				TCA	3.5, 7.0	w.s.p.	"	"
				asulam	1.0, 2.0	a.c.	"	19.4.79
								(post-em)
B	11.9.81	Perennial ryegrass		ethofumesate	1.4	e.c.	300	14.9.81
		(cv. Melle)	25	MBT	1.2	w.p.	"	(pre-em)
		White clover		bifenox	0.9, 1.8, 3.6	s.c.	"	"
		(cv. Grasslands Huia)	12	prosulfalin	0.5, 1.0, 2.0	w.p.	"	"
		P. trivialis	15	asulam	0.6, 1.2, 2.4	a.c.	"	"
		P. annua	15	pendimethalin	0.2, 0.4, 0.8	e.c.	"	"
		Stellaria media	17	fluorodifen	0.25, 0.5, 1.0	e.c.	"	"

* = seed of approximately 35% viability

MBT = methabenzthiazuron

Two field experiments were therefore set up at the Weed Research Organization (WRO) to test various herbicides for their potential selectivity between establishing ryegrass and P. annua, P. trivialis, A. myosuroides (Experiment A only) and S. media (Experiment B only); white clover was also included as a test species in the second experiment. The herbicides were chosen on the basis of previous preliminary screening and evaluation work at WRO (Blair, 1970; Blair, 1973a and b; Richardson et al., 1976; Kirkham & Richardson, 1981 and Oswald, unpublished). Pre- and post-emergnce sprays of ethofumesate were used as standard treatments in Experiment A, whilst both ethofumesate and methabenzthiazuron were included in Experiment B.

MATERIALS AND METHODS

Site preparation, sowing and spraying:- In both experiments seed of various species was sown in monocultures into a sandy loam soil using an Øyjord drill and herbicide treatments were sprayed at right angles across these. Seedbeds were prepared by ploughing and harrowing, during which granular fertiliser was incorporated into the seedbeds to give 20, 50 and 50 kg/ha of nitrogen(N), phosphate(P), and potash(K) respectively in Experiment A and 15, 72 and 72 kg/ha of N, P and K in Experiment B. Plots were rolled before and after sowing, leaving seed at a depth of about 1-1.5 cm in firm soil. Species plot widths were 1.5 m in Experiment A and 0.45 m in Experiment B and herbicide treaments were sprayed in 1.5 m wide swaths in both experiments. The position of each herbicide and species was randomised in a plaid design within each of two replicate blocks in Experiment A and three in Experiment B. Herbicides were applied either pre- or post-emergence in Experiment A but only pre-emergence treatments were tested in Experiment B. All treatments were applied with an Oxford Precision Sprayer fitted with 8002 Teejets and using propane to give a working pressure of 2.11 kg/cm2. Further details of sowing and spraying of each experiment are given in Table 1.

Soil conditions at and following pre-emergence spraying:- The soil was dry on the first spraying date in Experiment A (21 September, 1978) and very little rain fell subsequently until late November. The experiment area was irrigated with 13 mm of water on 26 October by which time the distribution of the seedlings of both Poa spp. was already patchy.

The soil was again dry during the seedbed preparation in Experiment B but sufficient rain fell during the two days following sowing to moisten the soil to a depth of several centimetres. Further light rain fell during spraying, turning to heavier and more continuous rain by the time the operation was complete.

Plant growth stage at post-emergence spraying in Experiment A:- At the first post-emergence spraying on 6 December about 40% of the plants of both Poa species had 3-4 tillers while the remainder were at the 1-3 leaf stage. These smaller plants appeared to have emerged in response to the irrigation. Of all the species sown ryegrass was the most uniform, both in growth stage and distribution of plants, about 90% of which consisted of 8-9 tillers. Establishment of Alopecurus myosuroides had also been satisfactory, with about 65% of the plants bearing 7-8 tillers and the remainder at the 2-3 leaf stage. All unsprayed plants of each species were well tillered by the time asulum was applied on 19 April 1979.

Site maintenance:- Volunteer broad-leaved weeds, mainly S.media, invaded both experiment areas during the establishment of the plots. Mecoprop at 1.4 kg a.e./ha was sprayed over the whole of Experiment A on 3

April 1979 and in Experiment B all plots except those sown with S.media were sprayed with benazolin at 0.2 kg a.i./ha on 14 April 1982. These overall treatments were followed by top dressings of compound fertiliser at 80, 35 and 35 kg/ha of N, P and K respectively in Experiment A (on 12 April) and 60, 20 and 20 kg/ha in Experiment B (on 14 April).

Assessment methods:- In both experiments the main assessment method was a visual score for the amount of green vegetation of each species present, 0 representing complete kill and 9 being equivalent to unsprayed control plots. Where growth on a sprayed plot was superior to that on unsprayed controls an appropriate score above 9 was given. Plots were assessed at regular intervals after spraying until early June by two independant observors, and the mean score was recorded on each occasion. A substantial population of Capsella bursa-pastoris survived overall spraying with benazolin in Experiment B and on 14 May 1982 each plot was assessed on a 0-9 scale for survival of this species. These results are included in Table 2.

Validation of the scoring technique:- In Experiment B, the accuracy of the scoring technique was checked on 16 November by counting the number of tillers of the appropriate grass, or trifoliate leaves of white clover, in two 30 cm. lengths of row chosen at random from within each plot. For S. media, a point quadrat was used, incorporating a single pin inclined at 32.5^{0} to the vertical; the number of hits to ground level of live vegetation were recorded from 48 points per plot. Six plots of each species were assessed per replicate, chosen to represent a cross-section of the scores given on the same day. The scores were then compared with the growth parameter measured for each species by regression analysis. Correlations were all highly significant (P=0.001), with r-values ranging from 0.861 for white clover to 0.930 for P. annua. The above procedure was repeated on 14 May but on this occasion all the plots were assessed. The data from these counts, expressed as % of unsprayed controls, are given in Table 2. The correlations between the two assessment methods were again highly significant, with r-values ranging from 0.801 for perennial ryegrass to 0.876 for P. annua. However, on the second occasion there was a strong tendency with all the species for scores to give proportionately lower values than did the counts, although these differences were less marked for scores nearest the top and bottom ends of the range. Nevertheless, the close correlations shown on both occasions between the visual scores and the objective assessment method used for each species imply that the score data can be used with confidence to show differences in herbicide effect both between species and between treatments.

The data from the visual scores are represented in graph form (Figs. 1-6, Experiment A; Figs. 7-12, Experiment B) and show the developement of and recovery from the effects of each herbicide on each species.

RESULTS AND DISCUSSION

Since one or both of the herbicides approved (Anon, 1983) for grass weed control in young leys were included as standard treatments in these experiments, it is important to establish whether or not they behaved characteristically.

Performance of the standard herbicides.

(1) Experiment A:-

(a) Pre-emergence ethofumesate (Fig. 1). Perennial ryegrass production was apparently unimpaired by ethofumesate applied pre-emergence at the lower dose but was noticeably depressed by the higher dose, although plants on these plots made almost complete recovery by early June. Both doses completely controlled all the weed grasses, although a few new plants of each species emerged during the following spring (Fig.1). These results agree closely with those of previous work (Hammond et al.,1976; Haggar & Bastian, 1976; Haggar & Kirkham, 1981; Kirkham & Haggar, 1982). Some reduction in the activity of ethofumesate might have been expected due to the dry soil conditions (McAuliffe & Appleby, 1981). However, the lowest dose used in Experiment A (1.7 kg a.i./ha) was marginally higher than the recommended rate of 1.4 kg a.i./ha (FBC Ltd, 1983) and this could have compensated for any reduction in activity that might have occurred (McAuliffe & Appleby, 1981).

(b) Post-emergence ethofumesate (Fig. 2). Applied post-emergence at 2.0 kg a.i./ha, ethofumesate gave good control of A. myosuroides but the effect against P. annua, although marked, was only transitory; P. trivialis was even less susceptible than P. annua to this treatment. A dose of 4.0 kg a.i./ha controlled both P. annua and A. myosuroides with only a slight, transitory depression in ryegrass growth, but P. trivialis survived even this dose. These poor results with post-emergence ethofumesate against P. trivialis are in line with some of those of Oswald (1980), working in herbage seed crops.

Both Poa species were much less susceptible to the post-emergence than pre-emergence treatments and this is in line with work by Haggar and Bastian (1976): they showed that P. annua was not only more sensitive to pre-emergence than post-emergence spraying with ethofumesate, but also that plants at the 2-3 leaf stage were significantly more susceptible than tillered plants.

Experiment B:-

Ethofumesate and methabenzthiazuron (both pre-emergence; Fig. 3). Both herbicides caused marked depressions in the early growth of ryegrass. This was particularly noticeable with methabenzthiazuron which reduced ryegrass growth until early spring, although it recovered rapidly thereafter (Fig. 7). Ryegrass showed a similar trend in response to ethofumesate but to a much lesser extent and by mid-May there appeared to be more ryegrass on these plots than on unsprayed controls (Table 2). The damage caused by both herbicides was more severe than in previous work (Haggar & Kirkham, 1981; Kirkham, 1981; Kirkham & Haggar, 1982). Rain falling onto wet soil during the spraying operation might have accounted for this by causing the herbicide to be leached to the sowing zone and thereby coming into contact with the seed (Leistra, 1980): both these herbicides have been shown to damage ryegrass if they contact the seed, particularly if this is already chitting (Haggar,1979b; Haggar & Passman, 1981). The toxicity to ryegrass of some of the other herbicides tested in Experiment B may also have been increased in the same way; for example, fluorodifen was much more damaging in Experiment A than in previous field work (Blair, 1970).

Ethofumesate and methabenzthiazuron showed equal activity against P. trivialis and both herbicides killed white clover. However, methabenzthiazuron was notably less effective than ethofumesate against P. annua and marginally less so against S. media and this is also consistent with the results of previous work (Haggar & Kirkham, 1981; Kirkham & Haggar, 1982). Ethofumesate had little effect on volunteer C. bursa-pastoris, but very few plants of this species survived spraying with methabenzthiazuron (Table 2).

Performance of the other herbicides.

Experiment A:-

1. Pre-emergence treatments (Fig. 1).

(a) metamitron. Metamitron was very effective against all the weed grasses, although at the lower dose it was less effective against A. myosuroides than was ethofumesate. Ryegrass production was noticeably depressed by both metamitron treatments but, as with ethofumesate, ryegrass had made almost complete recovery by the end of the assessment period. Recent work has confirmed the ability of pre-emergence metamitron, either alone or in mixture with methabenzthiazuron, to control P. annua selectively in a perennial ryegrass sward (Kirkham & Haggar, 1982).

(b) terbutryne. This herbicide showed a small margin of selectivity between ryegrass and P. trivialis at both doses used but it is doubtful whether this would be adequate to give selective control of the weed in practice. Neither of the other two weed grasses showed any promising susceptibility to the herbicide compared with ryegrass.

(c) carbetamide. Carbetamide showed no promising selectivity between ryegrass and any of the weed species in this experiment and in fact P. annua appeared to be slightly less susceptible than all the other species to the lower dose used. These results were disappointing since ryegrass showed far less tolerance to the herbicide than in previous work (Blair, 1973b). However, Blair used S23 perennial ryegrass as opposed to the cultivar Talbot used in this experiment, so it is possible that there may be varietal differences in ryegrass tolerance of carbetamide. This possibility is worth investigating since Blair showed such a high margin of selectivity with carbetamide between S23 and several indigenous grasses, including P. trivialis, and also since white clover was as tolerant as S23 of carbetamide applied pre-emergence in another experiment (Richardson & Parker, 1979).

2. Post-emergence treatments (Fig. 2).

(a) difenzoquat. This herbicide showed a margin of selectivity between ryegrass and P. annua equivalent to that given by ethofumesate at 2.0 kg a.i./ha, although the effects against the weed were equally transitory. Moreover, a high dose was necessary to achieve adeqate control and this caused a depression in ryegrass growth which persisted throughout the experiment. Neither dose had any effect on either P. trivialis or A. myosuroides. The potential of this herbicide for controlling P. annua in ryegrass swards has been confirmed in a two year-old sward (Haggar & Squires, 1979). However, as suggested by the present results, a high dose was necessary (up to 3.5 kg a.i./ha) and this is unlikely to be economic in practice.

(b) TCA. None of the species showed any marked response to TCA at either of the doses used.

(c) asulam. P. trivialis appeared to be slightly more susceptible to asulam than the other species tested, although the effect was only noticeable at the higher dose. However, work reported by Haggar and Squires (1979), along with more recent work in pots (Kirkham & Richardson, 1983), suggests that asulam might have given better results if applied at higher doses or at an earlier growth stage than in the present experiment. The work by Kirkham and Richardson (1983) also suggests that seedling white clover might be tolerant of asulam applied early post-emergence at doses sufficient to control both P. annua and P. trivialis.

Experiment B (all pre-emergence):-

(a) bifenox (Fig. 3). This herbicide showed promising selectivity between ryegrass and the two *Poa* species, particularly at the middle dose (1.8 kg a.i./ha), although *S. media* was unaffected and white clover was damaged severely by all the doses used. Volunteer *C. bursa-pastoris* was killed by all three bifenox treatments (Table 2).

Table 2. Grass tiller and white clover petiole counts, S. media point quadrat data and C. bursa-pastoris scores, all assessed on 13-14 May 1982 and expressed as % of unsprayed control (Expt. B)

Herbicide and dose (kg a.i./ha)		Perennial ryegrass	White clover	*Poa trivialis*	*Poa annua*	*Stellaria media*	*Capsella b-pastoris*
Ethofumesate	1.4	114	0	33	0	0	75
Methabenz-thiazuron	1.2	92	0	31	77	24	7
Bifenox	0.9	116	7	91	74	110	0
"	1.8	82	2	65	39	85	0
"	3.6	95	1	8	45	134	0
Asulam	0.6	84	87	94	79	107	79
"	1.2	95	111	46	81	82	89
"	2.4	79	44	42	47	76	71
Prosulfalin	0.5	78	99	24	32	103	45
"	1.0	31	126	3	2	92	27
"	2.0	3	84	0	0	16	4
Pendimathalin	0.2	93	51	35	69	53	62
"	0.4	92	26	27	35	38	14
"	0.8	35	2	1	11	1	7
Fluorodifen	0.25	82	91	39	74	99	0
"	0.5	78	50	25	44	93	0
"	1.0	54	35	2	24	114	0
S.E. (not applicable to zero values)		± 9.7	± 8.6	± 12.3	± 7.3	± 8.8	-

(b) asulam (Fig. 4). Both ryegrass and white clover showed considerable tolerance of asulam and a dose of 1.2 kg a.i./ha controlled *P. trivialis* with only a transient, although fairly severe, initial check to ryegrass. However, asulam showed little or no selectivity between the two crop species and either *P. annua* or *S. media* and had very little effect on *C. bursa-pastoris* at any of the doses used (Table 2).

(c) prosulfalin (Fig. 4). This herbicide had noticeably less effect on white clover than on all the other species tested, particularly the three grasses. Nevertheless, the lowest dose showed some selectivity between ryegrass and the two *Poa* species, with the effects against *P. annua* developing progressively over the whole assessment period. Prosulfalin showed only a slight margin of selectivity between clover and *S. media* and none at all between ryegrass and *S. media*. *C. bursa-pastoris* was controlled adequately only by the highest dose of the herbicide (Table 2). The high level of safety to clover and apparent long persistence shown by this herbicide make it an attractive candidate for further testing for control of Poa spp. in clover-based swards, especially since it's activity against ryegrass could be reduced by dressing seed with a safening compound, R-25788 (Richardson & Kirkham, 1982).

(d) pendimethalin (Fig. 4). All doses of pendimethalin suppressed ryegrass growth quite severely over the first few weeks after spraying, although this species had recovered almost completely from the two lower doses by early June. None of the other species recovered to the same extent, although P. annua tiller numbers recorded in mid-May suggested that this species had been affected marginally less than all the others except ryegrass (Table 2). Only the two higher doses had any notable effect on C. bursa-pastoris (Table 2). Despite the initial damage caused to ryegrass, this herbicide may be useful for control of P. trivialis in ryegrass seed crops where a short-term reduction in herbage production does not always result in loss of seed yield (Oswald, 1978).

(e) fluorodifen (Fig. 4). The lowest dose of fluorodifen showed some selectivity between ryegrass and P. trivialis, although ryegrass growth was severely depressed initially and recovered only slowly over the whole assessment period. White clover was marginally more susceptible than ryegrass but S. media was not affected by any of the doses used. Volunteer C. bursa-pastoris was eliminated by all fluorodifen treatments (Table 2).

CONCLUSIONS

These results suggest that the following herbicides are worthy of further testing:-

(a) Both in ryegrass/white clover and in pure ryegrass swards.

Asulam, pre-emergence, or post-emergence at higher doses or at an earlier growth stage than in Experiment A, for control of P. trivialis.

Prosulfalin, pre-emergence for control of both Poa spp. in ryegrass/clover swards; also in conjunction with ryegrass treated with R-25788.

b) In pure ryegrass swards only.

Metamitron, pre-emergence for control of both Poa spp. and A. myosuroides.

Bifenox, pre-emergence for control of both Poa spp.

Pendimethalin, pre-emergence for control of P. trivialis in ryegrass seed crops.

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FIG. 1. The effect of pre-emergence treatments on the growth of L. perenne and three weed grasses in Experiment A. (0 = complete kill, 9 = equivalent to unsprayed control).

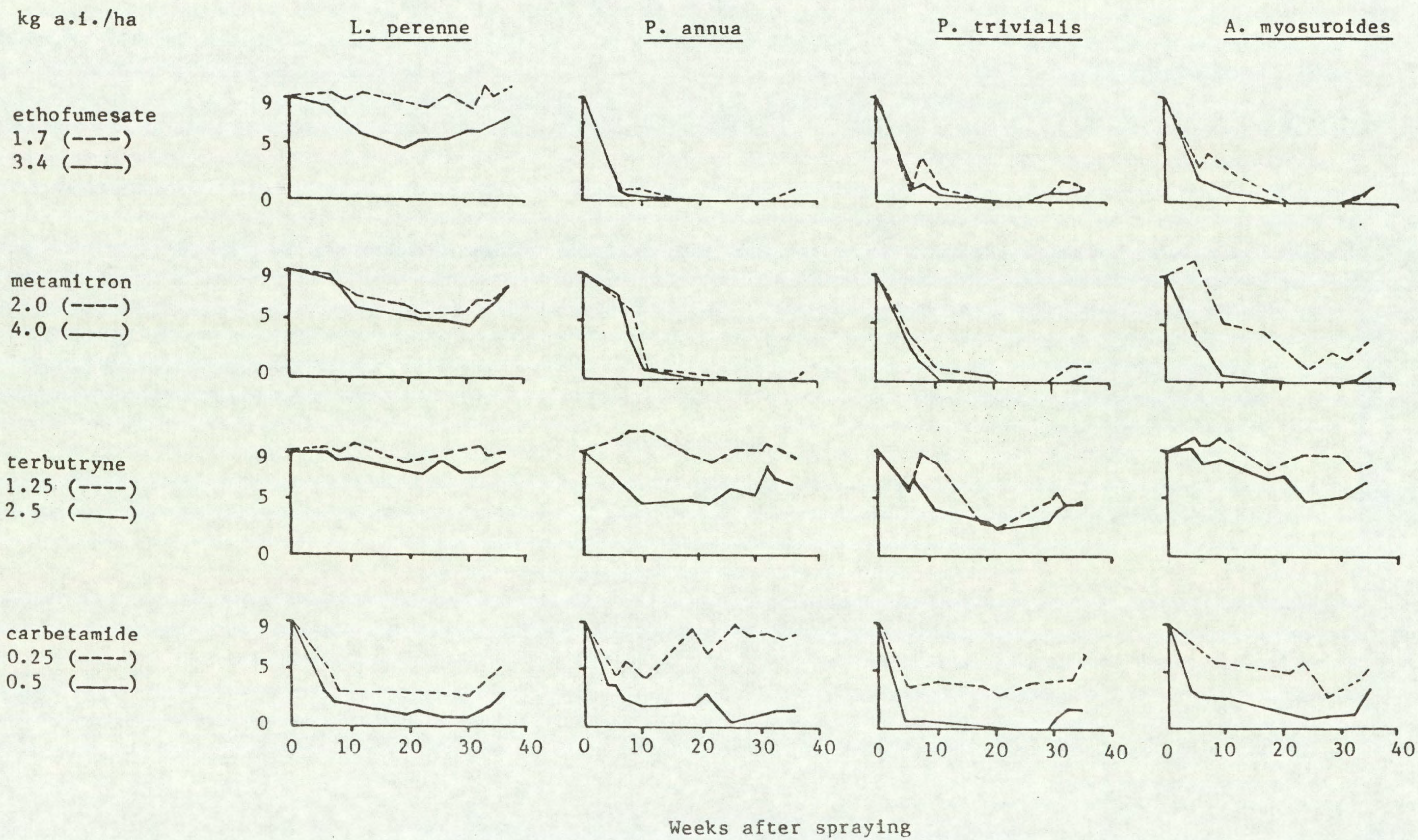


FIG. 2. The effect of post-emergence treatments on the growth of L. perenne and three weed grasses in Experiment A. (0 = complete kill, 9 = equivalent to unsprayed control).

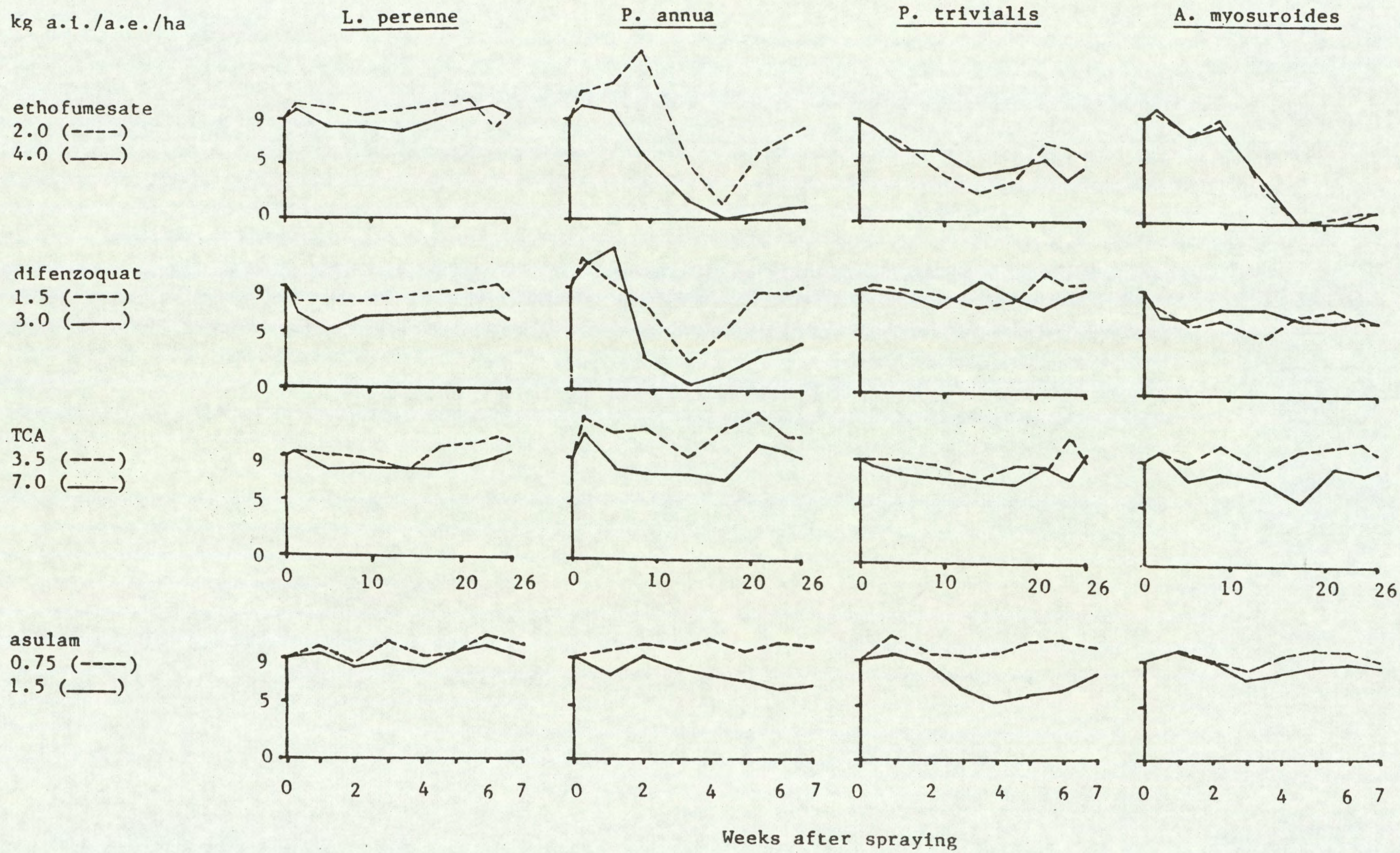


FIG. 3. The effect of pre-emergence spraying with ethofumesate, methabenzthiazuron or bifenox on the growth of <u>L. perenne</u>, <u>T. repens</u> and three weed species in Experiment B. (0 = complete kill, 9 = equivalent to unsprayed control).

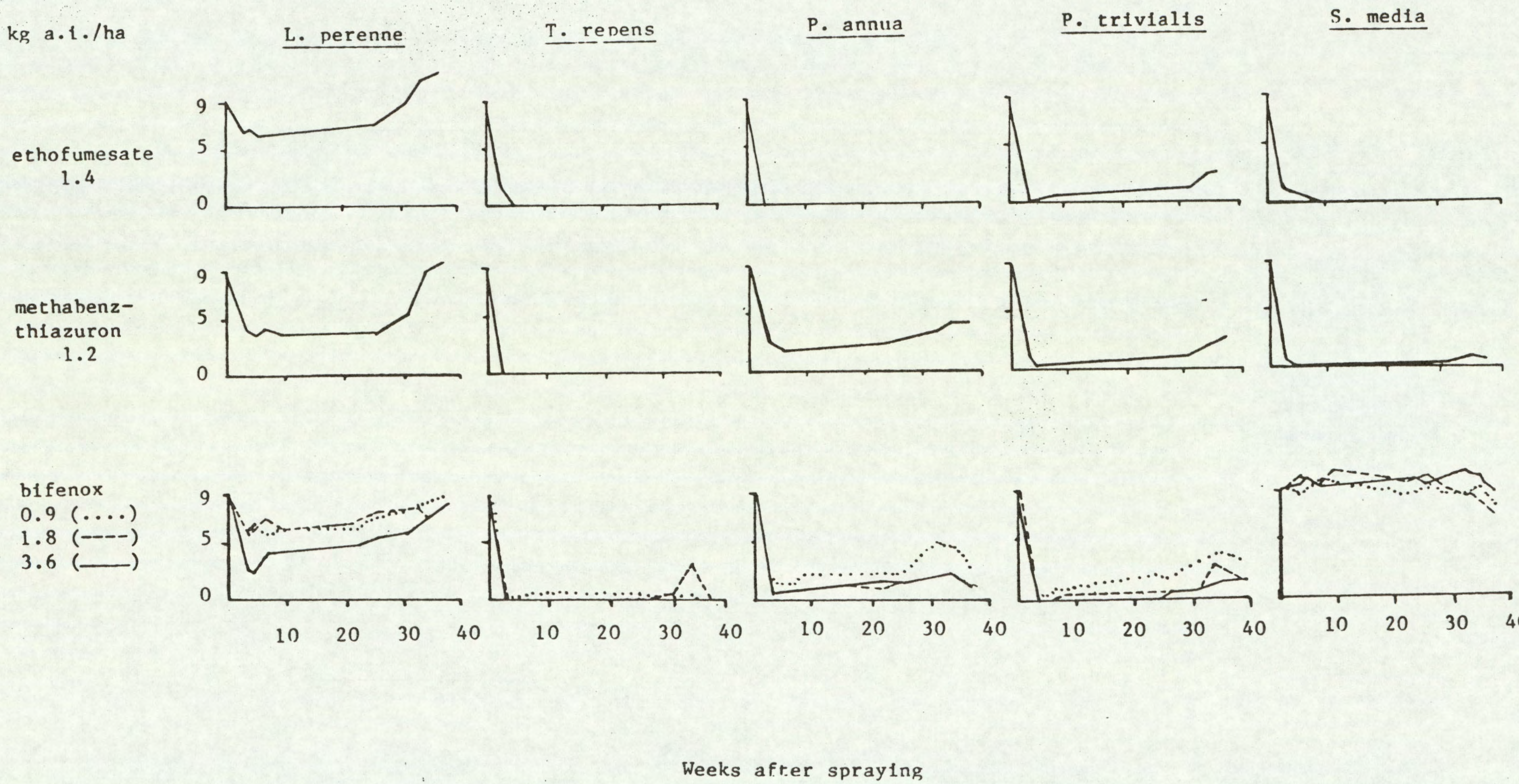
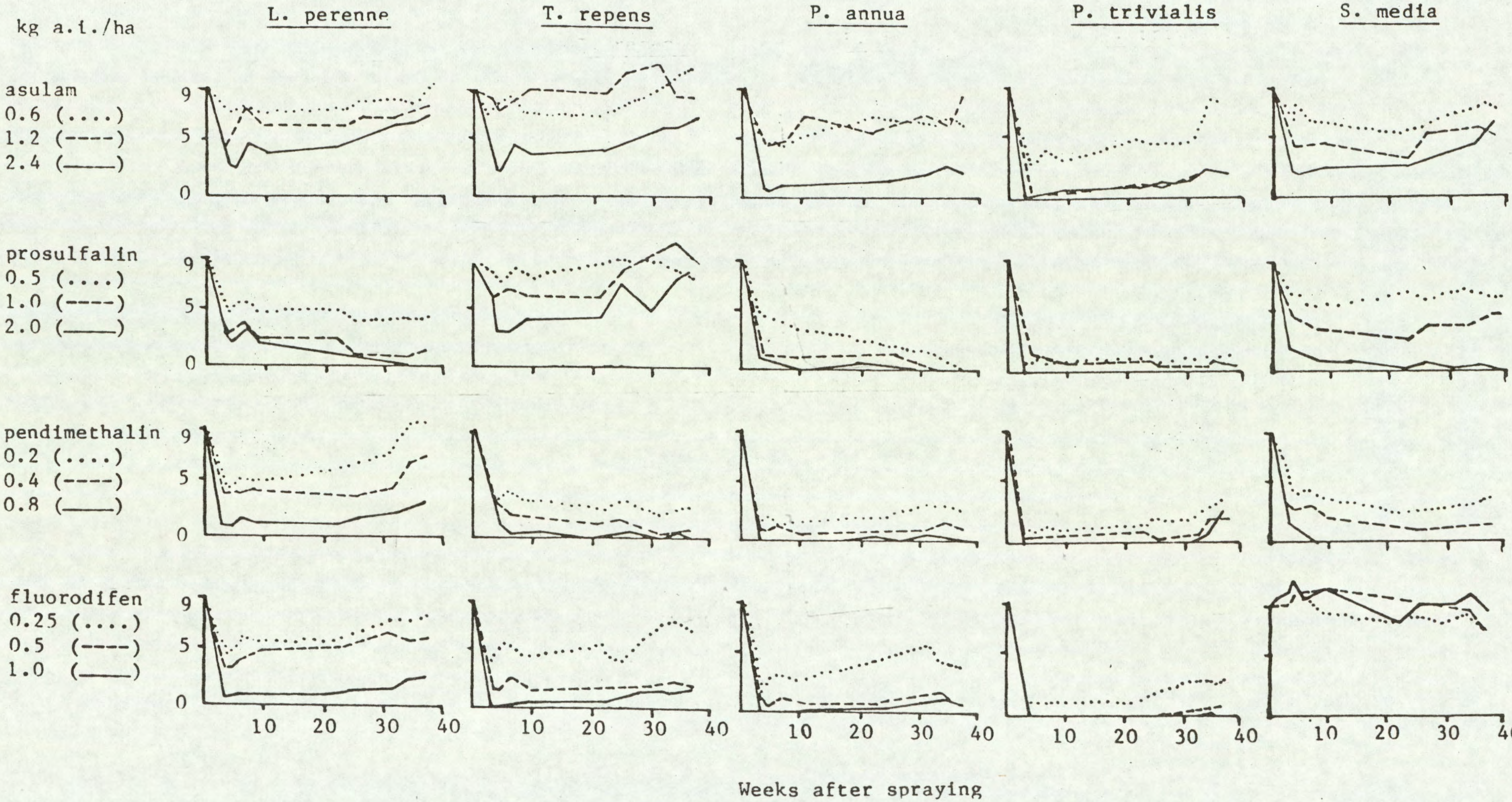


FIG. 4. The effect of pre-emergence spraying with asulam, prosulfalin, pendimethalin or fluorodifen on the growth of L. perenne, T. repens and three weed species in Experiment B. (0 = complete kill, 9 = equivalent to unsprayed control).



ABBREVIATIONS

ångström	Å
Abstract	Abs.
acid equivalent*	a.e.
acre	ac
active ingredient*	a.i.
approximately equal to*	≃
aqueous concentrate	a.c.
bibliography	bibl.
boiling point	b.p.
bushel	bu
centigrade	C
centimetre*	cm
concentrated	concd
concentration	concn
concentration x time product	ct
concentration required to kill 50% test animals	LC50
cubic centimetre*	cm^3
cubic foot*	ft^3
cubic inch*	in^3
cubic metre*	m^3
cubic yard*	yd^3
cultivar(s)	cv.
curie*	Ci
degree Celsius*	^oC
degree centigrade	^oC
degree Fahrenheit*	^oF
diameter	diam.
diameter at breast height	d.b.h.
divided by*	÷ or /
dry matter	d.m.
emulsifiable concentrate	e.c.
equal to*	=
fluid	fl.
foot	ft
freezing point	f.p.
from summary	F.s.
gallon	gal
gallons per hour	gal/h
gallons per acre	gal/ac
gas liquid chromatography	GLC
gramme	g
hectare	ha
hectokilogram	hkg
high volume	HV
horse power	hp
hour	h
hundredweight*	cwt
hydrogen ion concentration*	pH
inch	in.
infra red	i.r.
kilogramme	kg
kilo ($x10^3$)	k
less than	<
litre	l.
low volume	LV
maximum	max.
median lethal dose	LD50
medium volume	MV
melting point	m.p.
metre	m
micro ($x10^{-6}$)	μ
microgramme*	μg
micromicro (pico: $x10^{-12}$)*	μμ
micrometre (micron)*	μm (or μ)
micron (micrometre)*†	μm (or μ)
miles per hour*	mile/h
milli ($x10^{-3}$)	m
milliequivalent*	m.equiv.
milligramme	mg
millilitre	ml

† The name micrometre is preferred to micron and μm is preferred to μ.

millimetre*	mm
millimicro* (nano: $x10^{-9}$)	n or mμ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	>
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: $x10^{-12}$)	p or μμ
pint	pint
pints per acre	pints/ac
plus or minus*	±
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.

pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{\ }$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
<u>varietas</u>	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

WEED RESEARCH ORGANIZATION

TECHNICAL REPORTS
(Price includes surface mail; airmail £1.00 extra)
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6. The botany, ecology, agronomy and control of Poa trivialis L. rough-stalked meadow-grass. November 1966. G P Allen. Price - £0.25

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13. Changes in the germination capacity of three Polygonum species following low temperature moist storage. June 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. November 1971. A Phillipson. Price - £0.12

*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 Phillipson, T W Cox and J G Elliott. Price - £0.35

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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: bentazon, 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 (<u>Rumex obtusifolius</u> L.). November 1973. A M Blair and J Holroyd. Price - £1.06

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32. The activity and post-emergence selectivity of some recently developed herbicides: oxadiazon, 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

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

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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, chlornitrofen, 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, & M L Dean. Price - £4.00

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

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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

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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

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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

Since final typing of this report BSI has approved common names for HOE 33171 and HOE 35609. They are Fenoxaprop-ethyl (HOE 33171) and Fenthiaprop-ethyl (HOE 35609).