WEED RESEARCH ORGANIZATION

TECHNICAL REPORT No. 79

A PRELIMINARY STUDY ON THE EFFECT OF SOME AGRICULTURAL HERBICIDES ON A RANGE OF FIELD MARGIN FLORA

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November 1984

Price - £2.50

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ISSN 0511 4136
ISBN 0 7084 0316 6

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BIRNIE, J.E. A preliminary study on the effect of some agricultural herbicides on a range of field margin flora. Technical Report Agricultural and Food Research Council Weed Research Organization, 1984, 79, pp 16.

A PRELIMINARY STUDY ON THE EFFECT OF SOME AGRICULTURAL HERBICIDES ON A RANGE OF FIELD MARGIN FLORA

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SUMMARY

This report examines the effects of agricultural herbicides on plants found in uncropped field edges on farms. Pot-grown field margin plants, grasses and wild flowers, both annuals and perennials, are being screened at the WRO for their susceptibility to commonly applied herbicides. Seventeen species were treated with a range of herbicides including products with activity against grasses and broad-leaved weeds.

The most damaging herbicide treatment was mecoprop, which significantly damaged eight species. The least damaging treatment, for both grass and broad-leaved species, was flamprop-M-isopropyl. Sterile brome and common couch were not significantly affected compared to the unsprayed control by any herbicide treatment. The most susceptible species to the herbicides used in this experiment were hedge mustard and rough meadow-grass.

INTRODUCTION

Although there is a great deal of advice available on the effects of herbicides on both agricultural crops and field weeds, very little is known about their effect on the field margin flora.

The boundaries between fields are not farmed as such, nonetheless the plant species in this area may be affected by agricultural practices in adjacent fields. Increasingly, the farming community is realising that, far from being a nuisance to their agricultural business, hedgerows can be both useful and attractive areas of the farm. Hedgerows and their associated ground flora provide a varied habitat supporting many beneficial insect species (Sotherton, 1982), nesting sites for birds (Rands, 1982) and feeding grounds for many small mammals during winter months (Pollard and Relton, 1970), each of which is an integral part of the landscape of the countryside.

There are many local variations of field boundary, e.g. hawthorn hedge, dry stone wall, ditch and grass strip to name only a few, and each has some vegetation associated with it. The practical problems faced by the farmer trying either to improve or maintain an existing feature are many and, unfortunately, there is little or no information available to advise on management decisions concerning field margins.

The need for this information has been highlighted recently in the case of Bromus sterilis L., sterile brome. This annual grass is a common inhabitor of field edges. The fear of infestation of cereal crops and the known difficulty of controlling this grass weed in cereals has led to the widespread use of non-selective herbicides around field boundaries to remove unwanted vegetation. Bare ground favours annual species such as sterile brome, consequently populations have increased due to the lack of competition from perennial species.

Advice on herbicide application is limited to crop/weed effects; and, thus, the choice of chemical often will be made solely on the basis of its ability to control a particular field weed problem. Consideration must also be given to the impact of agricultural chemicals on the environment, in particular their effect on innoxious plants inhabiting non-agricultural areas on the farm.

Work at the Weed Research Organization, funded by the Perry Foundation, will provide essential information on the selectivity of a number of herbicides towards a wide range of grasses and wild flowers, both annuals and perennials, relevant to field margins.

A series of preliminary pot screening trials are in progress and the results of the first series are presented in this report. The majority of the plant species in this screening programme have no obvious agricultural role, though representatives of both crops and field weeds are also included.

It must be stressed that these trials are subject to the same limitations as all pot experiments in that results described do not necessarily reflect the field situation. However, they do provide useful comparative information which can be used as a basis for further research, enabling the farmers and their advisers to manage farming interests in a way which is sympathetic to the rural environment.

METHOD

A total of seventeen plant species were selected for the trial, representing seven families. The species in the screen were raised either from seed or were collected from field margins at Begbroke Hill Farm (Table 1). Those raised from seed were germinated on peat blocks in an unheated glasshouse. Four weeks after sowing the seedlings were transplanted into 7 cm plastic pots, one seedling per pot, containing a sandy loam soil. The presence of peat may have affected the uptake of chemical via the roots, though the results indicate that there was no reduction in herbicide activity. The transplants were moved outdoors on February 29: the mean minimum and maximum temepratures at this time were -0.9 °C and 5.2 °C respectively with a mean relative humidity of 80%. The species collected from the field margins were transplanted directly, one plant per pot, using the same soil described above. Herbicide treatments were applied on 2 May 1984. Growth stage details are given in Table 1. Treatments were applied to two replicates of each species at the recommended field rate for spring application (Table 2). The full range of herbicides was applied to all species, using a pot sprayer travelling at a constant forward speed of 1m/sec, fitted with a Spraying Systems 8002 Teejet nozzle at a pressure of 210 kPa, delivering a volume rate of 200 l/ha.

The use of a simple subjective scoring system was adopted to monitor herbicide damage. With such a wide range of plant species with differing growth rates and habits, a convenient way to assess the relative differences in vigour, between species and between herbicide treatments, is to score each species individually on a 0-9 scale for growth differences relative to the unsprayed control (Table 3). Assessments were carried out one week after spraying and at weekly intervals thereafter for a period of five weeks, the same assessor being used throughout. These data were subject to analyses of variance.

Table 1. Species list, origin of plant material and growth stage at time of treatment.

Common name	Latin name	Source: Seed	Source: Field margin	Growth stage
Cleavers	Galium aparine L.		*	5 branches
Cocksfoot	Dactylis glomerata L.	*		5 tillers
Common couch	Elymus repens (L.) Beauv.	*		4 tillers
Creeping bent	Agrostis stolonifera L.	*		Well tillered
False oat grass	Arrhenatherum elatius (L.) Beauv.	*		7 tillers
Field speedwell	Veronica persica Poiret	*		3 branches
Forget-me-not	Myosotis arvensis (L.) Hill		*	4 cm rosette
Garlic mustard	Alliaria petiolata (Bieb.)		*	Flowering
Hedge mustard	Sisymbrium officinale (L.) Scop.	*		10 leaves
Ox-eye daisy	Chrysanthemum leucanthemum L.	*		5 cm rosette
Perennial ryegrass	Lolium perenne L.	*		10 tillers
Red fescue	Festuca rubra L. subsp. rubra	*		8 tillers
Ribwort plantain	Plantago lanceolata L.	*		11 leaves
Rough meadow-grass	Poa trivialis L.	*		8 tillers
Slender false brome	Brachypodium sylvaticum (Huds.) Beauv.	*		3 leaves
Smooth meadow-grass	Poa pratensis L.	*		Well tillered
Sterile brome	Bromus sterilis L.	*		6 tillers

Table 2. Details of herbicide treatments applied to a range of field margin flora

Herbicide	Product (Tradenames)	Dose kg a.i./ha (kg a.e./ha)	Formulation
Mecoprop	Compitox Extra*	2.40	K salt
loxynil+bromoxynil	Deloxil**	0.76	ester e.c.
Chlorsulfuron	Glean DF20***	0.02	wettable powder
Clopyralid	Format+	(0.20)	amine salt
Isoproturon	Arelon Liquid**	1.88	s.c.
Diclofop-methyl	Hoegrass**	1.14	e.c.
Flamprop-M-isopropyl	Commando++	0.60	e.c.

*May & Baker Ltd, **Hoechst Ltd, ***Du Pont Ltd, +Murphy Shield Ltd, ++Shell Ltd.

Table 3. Criteria by which vigour of species is visually assessed following herbicide treatment

0 = Dead
1 = Moribund, not all tissue dead
2 = Live, some green tissue, further growth unlikely
3 = Gross inhibition of growth, recovery unlikely
4 = Slight inhibition of growth
5 = Obvious growth defect, e.g. epinasty
6 = Slight growth differences, e.g. wilting, chlorosis
7 = Colour difference, yellowing or darkening
8 = Slight detectable growth difference
9 = Indistinguishable from unsprayed control

RESULTS AND DISCUSSION

Effect of herbicide treatments: Figures A-G show the effects of individual herbicides on the plant species tested over a five-week period after treatment.

In general, the results achieved were consistent with expectations, broad-leaved weed herbicides affecting the broadleaved species and grass weed herbicides affecting the grasses. Table 4 shows the effect of each herbicide on field margin grasses. Table 5 shows the effect of each herbicide on broad-leaved species, the most susceptible species at the top of each column.

Mecoprop: (N) (±) 2-(4-chloro-2-methylphenoxy)propionic acid

Most species in the screen were affected to some extent. Slender false brome, rough meadow-grass and creeping bent were more susceptible than the other grasses. Slender false brome had only reached the three leaf stage at time of spraying which may account for the severity of damage recorded. Inhibition of growth exhibited by creeping bent and rough meadow-grass is more difficult to explain: it could possibly be due to the very high dose of mecoprop applied. Of the broad-leaved species, cleavers, hedge mustard, hedge garlic and ribwort plantain were all significantly more damaged than the untreated control and all other species with the exception of slender false-brome. Mecoprop was the most damaging of all the herbicide treatments in terms of numbers of species significantly affected compared to the untreated controls.

Isoproturon: (N) 3-(4-isopropylphenyl)-1,1-dimethylurea

This herbicide affected all grass species with the exception of common couch, sterile brome, red fescue and cocksfoot, whilst ox-eye daisy was the only broad-leaved species to be significantly reduced in vigour compared to the unsprayed control. Forget-me-not was also damaged but just failed to reach significance. Of those grass species which were affected only rough meadow-grass and perennial ryegrass are susceptible species according to the manufacturer's label recommendations (Hoechst, 1984a).

Chlorsulfuron: (N) 2-chloro-N[[(4-methoxy-6-methyl-1,3,5-triazine-2-yl)amino] carboxyl] benzenesulphonamide

Cleavers was significantly more damaged than any other species in the screen. Other species affected were hedge mustard, forget-me-not, perennial ryegrass, rough meadow-grass and garlic mustard though none died. The least affected species included common speedwell, false oatgrass, sterile brome, smooth meadow-grass and common couch.

Chlorsulfuron, even at the high dose used, appears to be 'safe' to the majority of species in this screen, but not to cleavers. Control of the latter may seem to be an advantage but indications are that hedgerow cleavers are not a source of infestation of arable fields (Froud-Williams, pers. com.).

Diclofop-methyl: (N) methyl-2-[4-(2,4-dichlorophenoxy)phenoxy]propionate

The grass species most affected by this herbicide were: perennial ryegrass, false oat grass, cocksfoot and red fescue. Of the other grass species, rough meadow-grass was slightly affected at two weeks after treatment but made steady recovery during the following weeks. Apparently, this grass is only susceptible up to emergence of the first tiller (Hoechst, 1984b). The only broad-leaved species to be significantly affected was hedge garlic.

Clopyralid: 3,6-dichloro-2-pyridine carboxylic acid

This herbicide is specific to broad-leaf species, affecting only ribwort plantain, ox-eye daisy and cleavers. The only grass to be significantly affected compared to the unsprayed control was creeping bent which was also more damaged than the following: perennial ryegrass, hedge mustard, false oat grass, slender false brome and red fescue. The narrow spectrum of weeds affected by this chemical at the dose rate used under pot experiment conditions indicates that minimal damage would occur in the field where herbicide activity would be reduced.

Flamprop-M-isopropyl: (N) isopropyl-N-benzoyl-N-(3-chloro-4-fluorophenyl)-D-alaninate

Like diclofop-methyl, flamprop-M-isopropyl was grass-specific with false oat grass, cocksfoot, and rough meadow-grass being significantly reduced in vigour compared to the untreated control. All other species in the screen, except those mentioned above, were significantly less damaged than false oat grass. None of the grass species above are mentioned on the manufacturer's product label. Though primarily used as a wild oat herbicide, it also has some effect in controlling Arrhenatherum elatius var. bulbosum, onion couch (Shell, 1984). The non-bulbous variety of false oat grass was the only grass to be severely affected by this chemical.

Ioxynil + bromoxynil: (N) 4-hydroxy-3,5-di-iodobenzonitrile + (N) 3,5-dibromo-4-hydroxybenzonitrile

The activity of the herbicide mixture was restricted to garlic mustard, forget-me-not and common speedwell. All were reduced in vigour compared to the unsprayed control and all were more damaged than every other species in the screen. Both forget-me-not and common speedwell are susceptible at growth stages up to 6 true leaves (MAFF, 1982) at the dose rate applied in this experiment. Although these species were treated outside the recommended growth stage, the increased activity achieved in pots gave successful control.

CONCLUSIONS

Mecoprop was the most damaging herbicide treatment to a wide range of species. Though the actual dose of chemical reaching field margins may be small during one spraying operation, there is no evidence to suggest that multiple applications of chemical throughout the season will not have a cumulative effect on the field edge plants. If the field weed spectrum allows, the use of an alternative herbicide, e.g. ioxynil + bromoxynil which affects fewer species, or a reduced rate of mecoprop - would be preferable, especially if there are known to be susceptible species growing at the field edge.

Both flamprop-M-isopropyl and diclofop-methyl may be worthy of further investigation as chemical agents to restrict grass growth, so reducing competition with the broad-leaved species in the margins. Expansion of the present programme to develop these herbicides, and other chemicals with similar growth retardant properties, as management tools will be possible if more resources become available for this type of research.

The main reason for deliberate herbicide application into field boundaries is for the control of potential field weed problems, e.g. sterile brome, but none of the chemicals so far tested are able to selectivity control this grass.

Investigations will continue for the next two years, during which time we hope to be able to test a range of chemicals of contrasting modes of action against a wider range of wild plant species. An increased awareness of both the positive and negative effects of agricultural chemicals on non-crop species will not only benefit agriculture but the countryside as a whole.

ACKNOWLEDGEMENTS

I would like to thank Dr E J P Marshall for his help in choosing the treatments, Mr G A Bird for practical assistance, Mr C J Marshall for statistical advice and Mr P J Terry for his helpful criticism of this report.

REFERENCES

HOECHST LTD. (1984a) Hoegrass. Product label recommendations.
HOECHST LTD. (1984b) Arelon. Product label recommendations.
MAFF (1982) Weed control in cereals. Autumn/Winter 1982-3. Advisory booklet 2253 (82-83), 14-15.
POLLARD, E. and RELTON, J. (1970) Hedges IV: A study of small mammals in hedges and cultivated fields. Journal of Applied Ecology, 7, 549-557.
RANDS, M.R.W. (1982) The importance of nesting cover quality to partridges. Game Conservancy Annual Review 1981, 13, 58-64.
SHELL LTD. (1984) Commando. Product label recommendations.
SOTHERTON, N.W. (1982) The value of field boundaries to beneficial insects. Game Conservancy Annual Review 1981, 13, 52-54.

Table 4. The susceptibility of field margin grass species to seven herbicides five weeks after treatment. Species in italics are significantly reduced in vigour compared to the unsprayed contol. (Score values, mean of two replicates).

mecoprop		isoproturon		chlorsulfuron		diclofop-methyl		clopyralid		ioxynil + bromoxynil		flamprop-M-isopropyl	
B.sylvaticum	(1.5)	*A.stolonifera*	(0.0)	*L.perenne*	(4.5)	*L.perenne*	(2.0)	*A.stolonifera*	(5.5)	A.stolonifera	(9.0)	*A.elatius*	(3.0)
A.stolonifera	(3.5)	*A.elatius*	(1.0)	*P.trivialis*	(5.0)	*A.elatius*	(3.0)	P.trivialis	(8.0)	A.elatius	(9.0)	*D.glomerata*	(4.0)
P.trivialis	(4.5)	*B.sylvaticum*	(1.0)	A.stolonifera	(6.0)	*D.glomerata*	(3.0)	B.sterilis	(8.0)	B.sylvaticum	(9.0)	*P.trivialis*	(5.0)
D.glomerata	(7.0)	*P.trivialis*	(1.5)	D.glomerata	(6.0)	*F.rubra*	(4.0)	E.repens	(8.0)	B.sterilis	(9.0)	F.rubra	(6.0)
F.rubra	(8.0)	*P.pratensis*	(2.5)	F.rubra	(6.0)	A.stolonifera	(7.0)	D.glomerata	(8.5)	D.glomerata	(9.0)	A.stolonifera	(7.0)
A.elatius	(8.0)	*L.perenne*	(3.0)	B.sylvaticum	(6.5)	P.trivialis	(7.5)	L.perenne	(9.0)	F.rubra	(9.0)	E.repens	(8.0)
B.sterilis	(8.5)	F.rubra	(7.5)	E.repens	(7.0)	E.repens	(8.0)	P.pratensis	(9.0)	P.pratensis	(9.0)	B.sylvaticum	(8.5)
L.perenne	(8.5)	B.sterilis	(9.0)	B.sterilis	(9.0)	B.sylvaticum	(8.0)	F.rubra	(9.0)	P.trivialis	(9.0)	L.perenne	(8.5)
P.pratensis	(9.0)	D.glomerata	(9.0)	A.elatius	(9.0)	P.pratensis	(9.0)	B.sylvaticum	(9.0)	F.rubra	(9.0)	B.sterilis	(9.0)
E.repens	(9.0)	E.repens	(9.0)	P.pratensis	(9.0)	B.sterilis	(9.0)	A.elatius	(9.0)	E.repens	(9.0)	P.pratensis	(9.0)

S.E. treatments X control 1.223

Table 5. The susceptibility of field margin broad-leaved species to seven herbicides five weeks after treatment. Species in italics are significantly reduced in vigour compared to the unsprayed control. (Score values, mean of two replicates).

mecoprop	isoproturon	chlorsulfuron	diclofop-methyl	clopyralid	ioxynil bromoxynil	flamprop-M-isopropyl
G.aparine (0.0)	*C.leucanthemum* (1.5)	*G.aparine* (0.0)	*A.petiolata* (5.5)	*P.lanceolata* (0.5)	*V.persica* (2.5)	P.lanceolata (6.5)
S.officinale (0.0)	P.lanceolata (6.0)	*S.officinale* (3.5)	C.leucanthemum (7.5)	*C.leucanthemum* (1.5)	*A.petiolata* (3.5)	A.petiolata (9.0)
P.lanceolata (1.0)	G.aparine (3.0)	*M.arvensis* (4.0)	G.aparine (8.5)	G.aparine (7.5)	*M.arvensis* (4.5)	C.leucanthemum (9.0)
A.petiolata (1.0)	A.petiolata (8.0)	*A.petiolata* (5.0)	S.officinale (8.5)	V.persica (7.5)	C.leucanthemum (7.5)	G.aparine (9.0)
C.leucanthemum (4.5)	M.arvensis (9.0)	P.lanceolata (6.0)	P.lanceolata (8.5)	M.arvensis (7.5)	S.officinale (7.5)	M.arvensis (9.0)
V.persica (7.5)	V.persica (9.0)	C.leucanthemum (6.0)	V.persica (9.0)	A.petiolata (7.5)	P.lanceolata (7.5)	S.officinale (9.0)
M.arvensis (9.0)	S.officinale (9.0)	V.persica (8.0)	M.arvensis (9.0)	S.officinale (9.0)	G.aparine (9.0)	V.persica (9.0)

S.E. treatments X control 1.223

FIGURE A.

The effect of mecoprop applied at the rate of 2.4 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

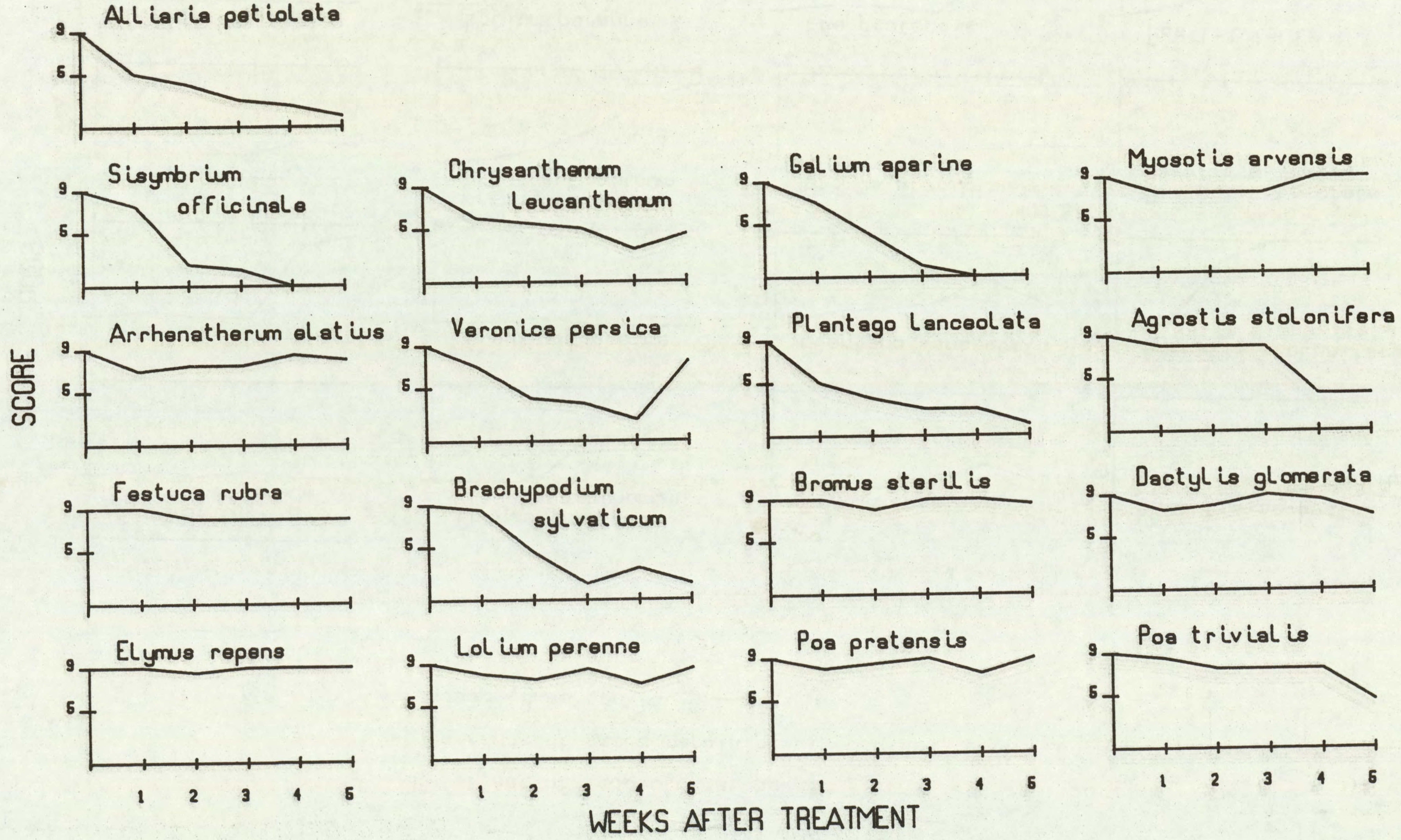


FIGURE B.

The effect of isoproturon applied at the rate of 1.88 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

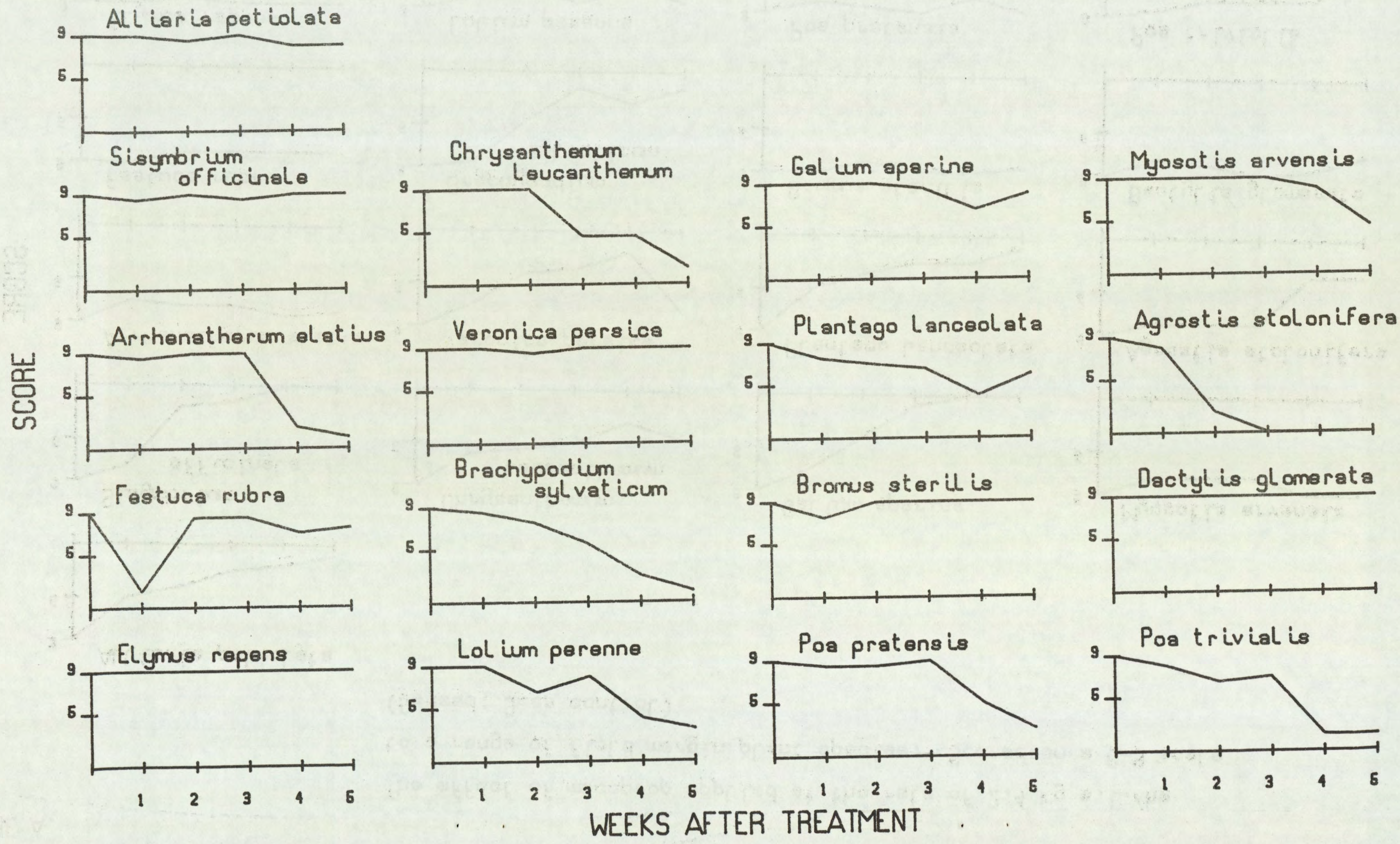


FIGURE C.

The effect of chlorsulfuron applied at the rate of 0.02 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

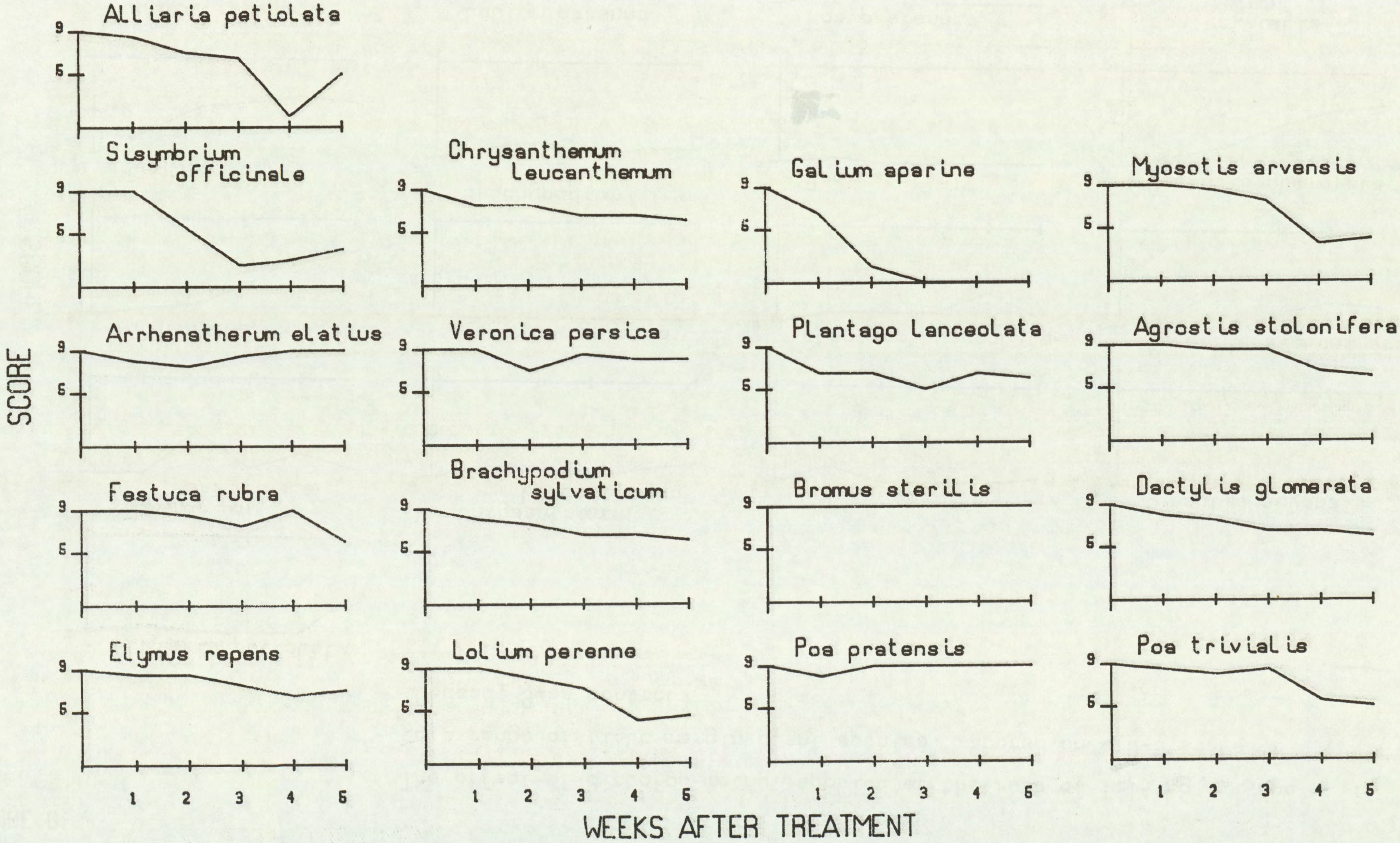


FIGURE D.

The effect of diclofop-methyl applied at the rate of 1.14 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

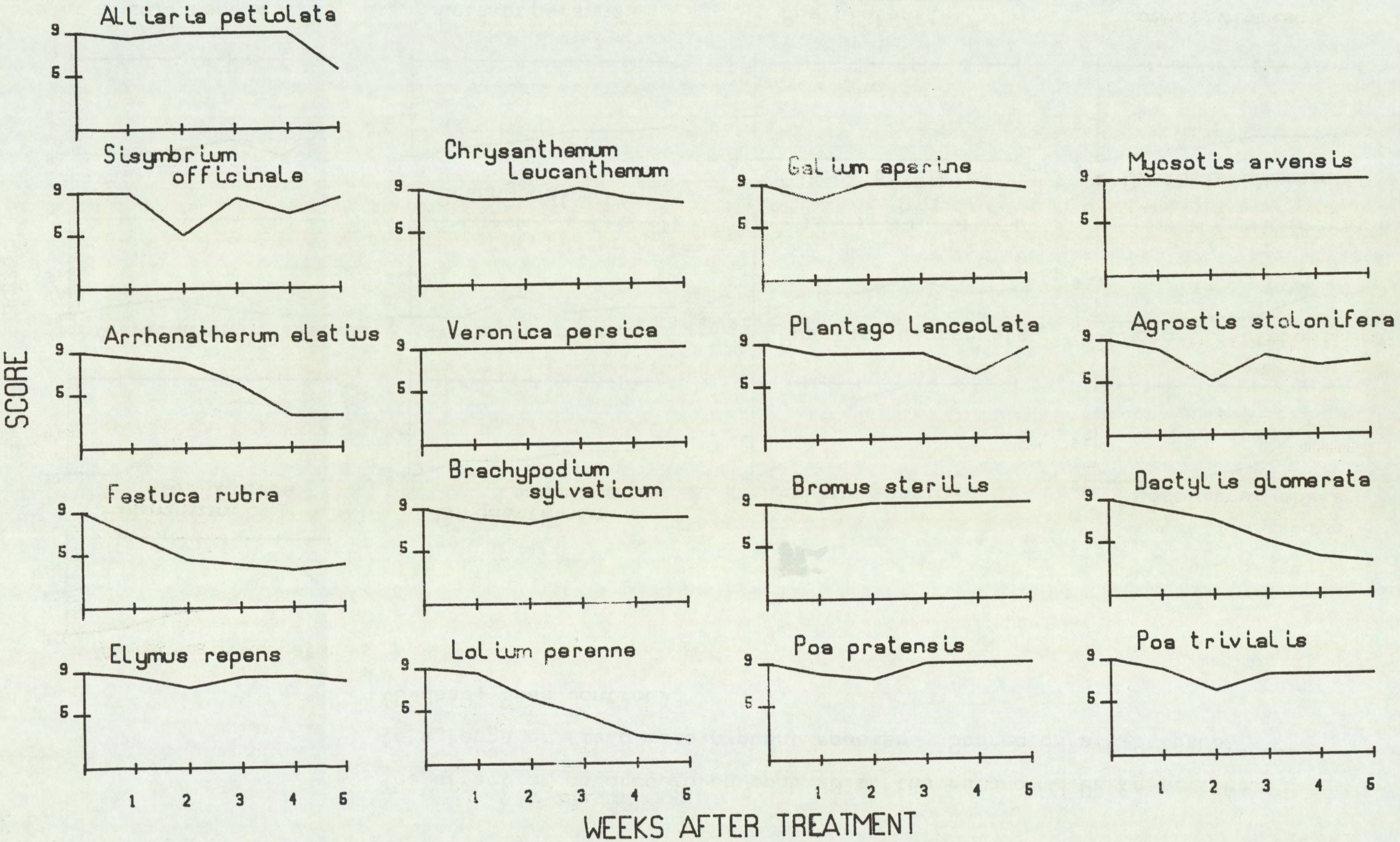


FIGURE E.

The effect of clopyralid applied at the rate of 0.20 kg a.e./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

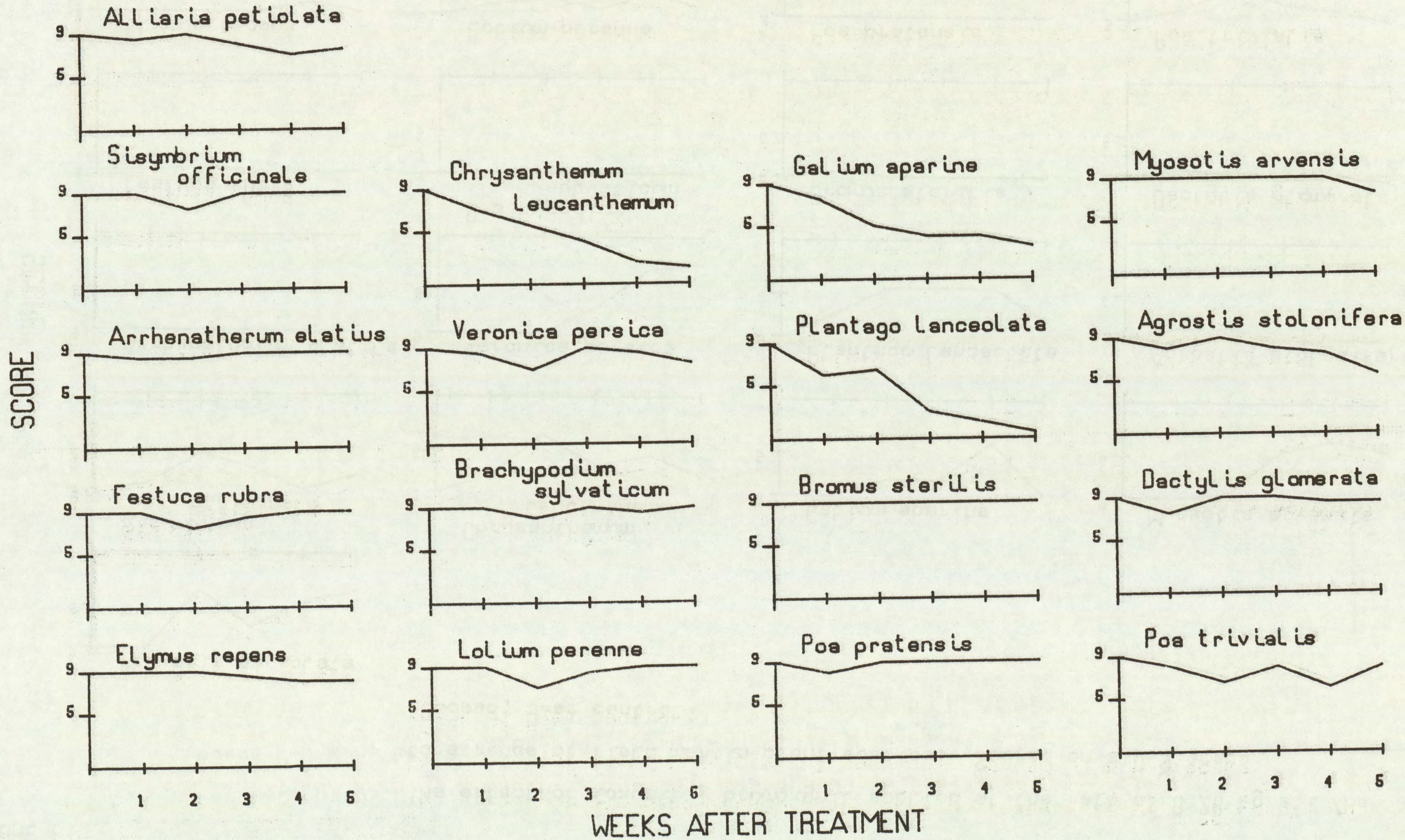


FIGURE F.

The effect of ioxynil + bromoxynil applied at the rate of 0.76 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)

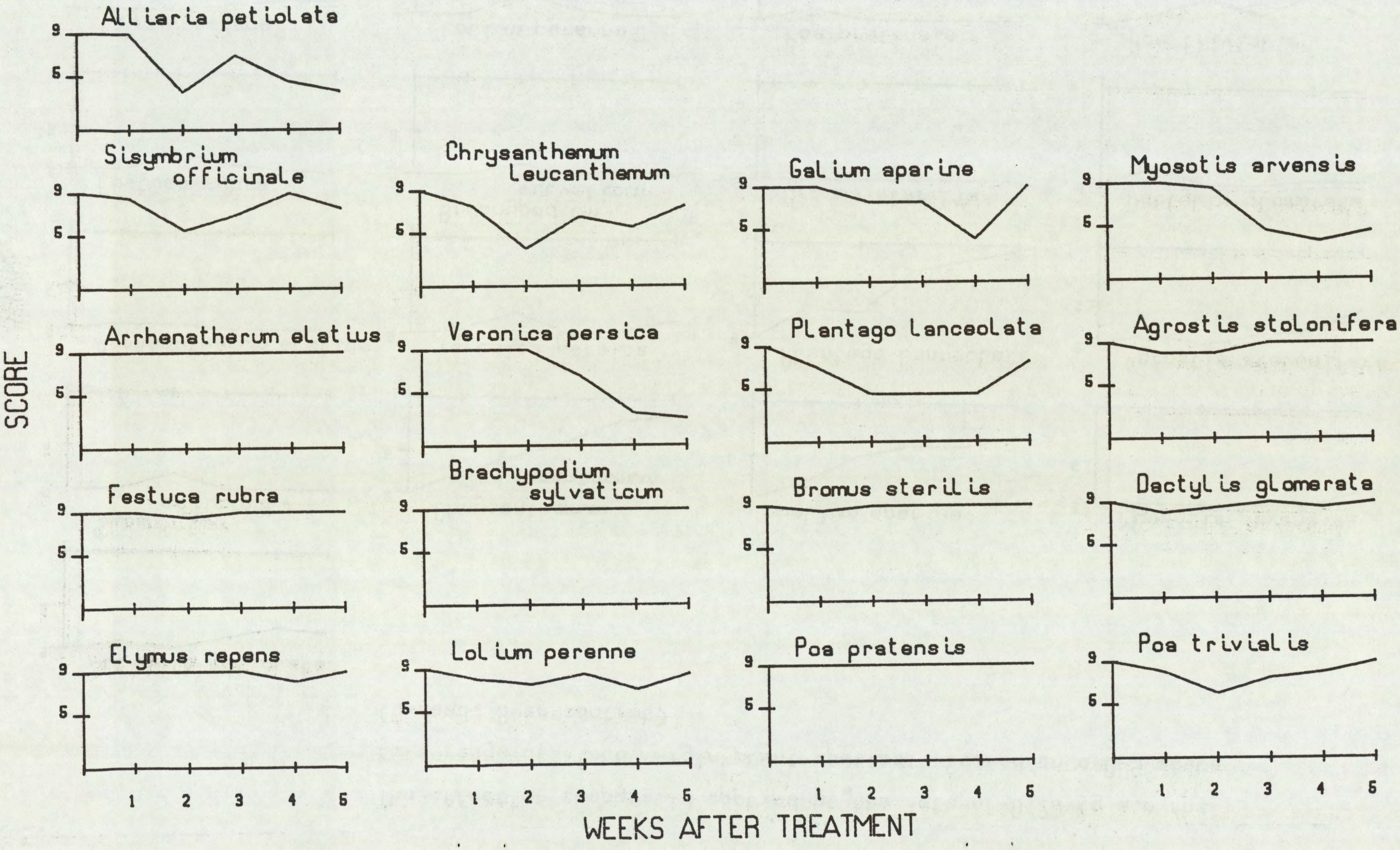
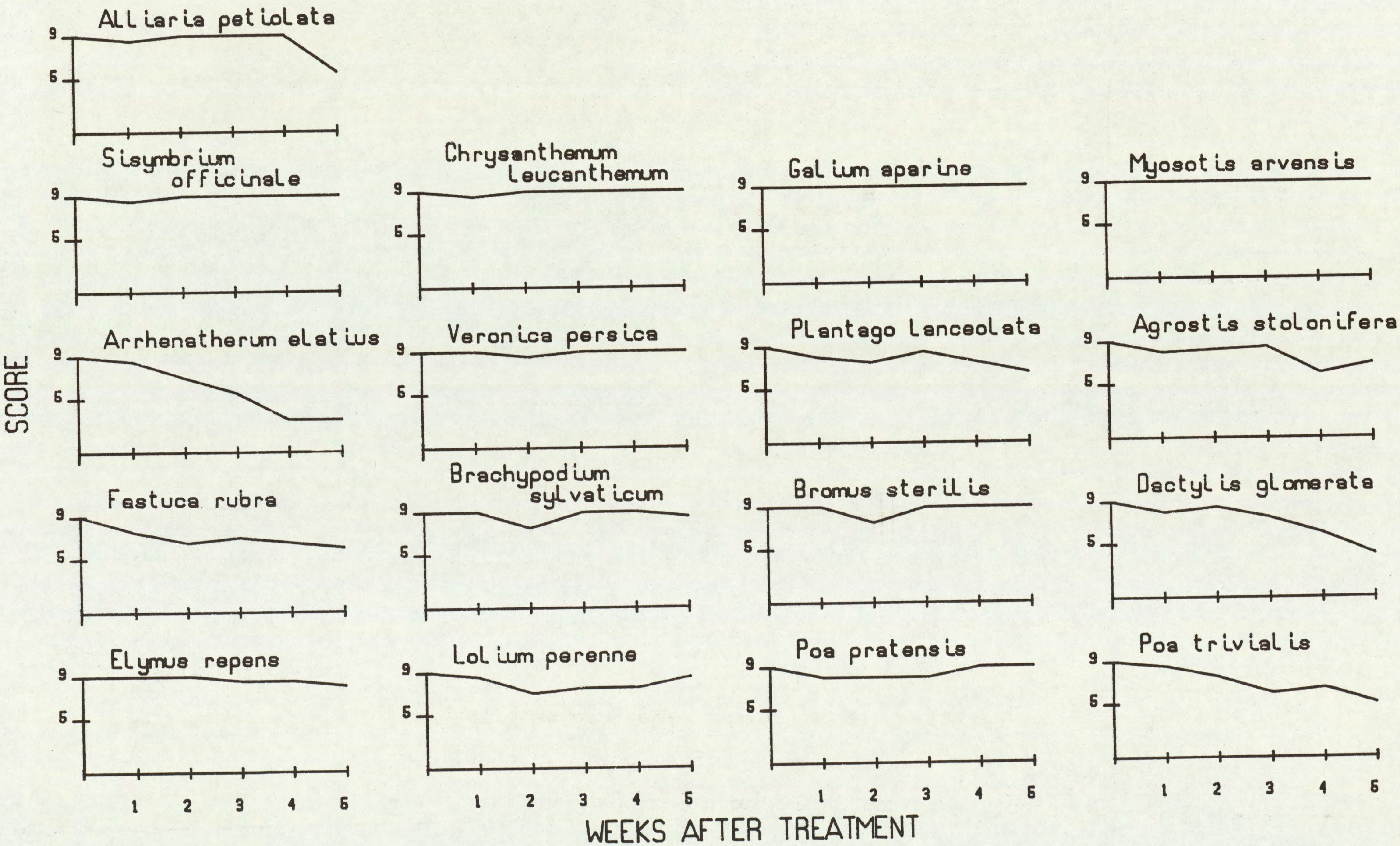


FIGURE G.

The effect of flamprop-M-isopropyl applied at the rate of 0.60 kg a.i./ha to a range of field margin plant species. Scored on a 0-9 scale (0=dead; 9=as control)



ABBREVIATIONS

ångström	Å
Abstract	Abs.
acid equivalent*	a.e.
acre	ac
active ingredient*	a.i.
approximately equal to*	$\simeq$
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*	^{o}C
degree centigrade	^{o}C
degree Fahrenheit*	^{o}F
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.
varietas	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.

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