1987 British Crop Protection Conference
Weeds

Volume 3

1987
British Crop Protection Conference
Weeds

Volume 3

Proceedings of a Conference held at
Brighton Metropole, England
November 16–19, 1987

BCPC Publications
20 Bridport Road
Thornton Heath
Surrey CR4 7QG, UK

British Library Cataloguing in Publication Data
British Crop Protection Conference – Weeds (1987)
Proceedings – British Crop Protection
Conference – Weeds – 1987
1. Weeds – Control
I. Title
632′.58 SB611

ISBN 0-948404-19-1
ISBN 0-948404-16-7 v.1
ISBN 0-948404-17-5 v.2
ISBN 0-948404-18-3 v.3

ISSN 0144-1604

Printed in Great Britain by
THE LAVENHAM PRESS LIMITED, LAVENHAM, SUFFOLK

Contents

VOLUME 1

SESSION I

SESSION 2

NEW HERBICIDE MOLECULES

SESSION 3A

CEREAL CROP MANAGEMENT TECHNIQUES: EFFECT ON WEEDS AND WEED CONTROL

Invited Papers

Research Reports

SESSION 3B

MODE OF ACTION AND METABOLISM OF HERBICIDES: I

Invited Papers

Research Reports

SESSION 4B

MODE OF ACTION AND METABOLISM OF HERBICIDES: II

VOLUME 2

SESSION 4C

CEREALS – THE IMPORTANCE OF WEED SPECIES AND CONTROL THEREOF

SESSION 5

HERBICIDE RESISTANCE IN CROPS AND WEEDS: I

Invited Papers

SESSION 6

HERBICIDE BEHAVIOUR IN SOIL: I

Invited Papers and Research Reports

SESSION 7A

HERBICIDE BEHAVIOUR IN SOIL: II

Invited Papers

SESSION 7B

WEED CONTROL IN VEGETABLES AND FRUIT

Posters

SESSION 7C

BIOLOGY OF WEED SEED

Invited Papers

Poster

VOLUME 3

SESSION 8A

WEED CONTROL IN PASTURE, UPLAND GRASS AND AGRO-FORESTRY

Posters

SESSION 8B

WEED CONTROL IN OIL PRODUCING AND PROTEIN CROPS

Posters

SESSION 8C

HERBICIDE RESISTANCE IN CROPS AND WEEDS: II

SESSION 9A

WEED COMPETITION AND THRESHOLDS – FUNDAMENTAL ASPECTS OF COMPETITION AND POPULATION DYNAMICS

SESSION 9B

MODE OF ACTION AND METABOLISM OF HERBICIDES: III

Research Reports

SESSION 10A

WEED COMPETITION AND THRESHOLDS – PRACTICAL APPLICATIONS OF WEED THRESHOLDS

Research Reports

SESSION 10B

MODE OF ACTION AND METABOLISM OF HERBICIDES: III (Continued)

Research Reports

THE BRITISH CROP PROTECTION COUNCIL

President	Professor R. L. Bell
Chairman	Mr R. F. Norman
Vice Chairmen	Mr B. W. Cox, Mr D. J. Higgons
Hon. Treasurer and Secretary	Dr Q. A. Geering

Corporate Members:
Agricultural and Food Research Council (2)
Association of Applied Biologists (1)
Agricultural Engineers' Association (1)
Association of Independent Crop Consultants (1)
British Agrochemicals Association (2)
British Institute of Agricultural Consultants (1)
British Society for Plant Pathology (1)
Department of Agriculture and Fisheries (2)
    for Scotland
Department of Agriculture, Northern Ireland (1)
Department of the Environment (1)
Ministry of Agriculture, Fisheries and Food
    Agricultural Development and Advisory
    Service (2)
    The Harpenden Laboratory (1)
    Pesticide Branch (1)
National Association of Agricultural Contractors (2)
National Farmers' Union (2)
Natural Environment Research Council (1)
Overseas Development Administration (2)
Society of Chemical Industry, Pesticides Group (1)
United Kingdom Agricultural Supply Trade (2)
    Association Ltd

Individual Members:
Dr J. T. Braunholtz
Dr D. H. S. Drennan
Professor J. D. Fryer
Dr H. C. Gough
Mr A. G. Harris
Dr K. Holly
Mr J. Smith

Hon. Vice-Presidents
Mr A. W. Billitt
Mr S. A. Evans
Mr E. Lester

The British Crop Protection Council

The British Crop Protection Council exists to promote the knowledge and understanding of crop protection. It was founded in 1968 when the British Weed Control Council, set up in 1953, and the British Insecticide and Fungicide Council, set up in 1962, merged to form a single body concerned with all aspects of crop protection. The BCPC is essentially a British organisation but its work is rapidly becoming international in outlook.

The Council is composed of corporate members including Government bodies, research and advisory services, the farming and agrochemical industries, distribution and contracting services, environmental bodies and other organisations, as well as individual members with special qualifications and experience in the field of crop protection. This blend is probably unique.

Objectives

Members of The BCPC have a common objective—to promote and encourage the science and practice of pest, disease and weed control, and allied subjects both in the UK and overseas. To achieve this the Council aims:

to compile and arrange the publication of information and recommendations on crop protection for specialists;

to help the public to understand the nature of pests, diseases and weeds, and their control, and the part their control plays in food production;

to provide a forum for discussion at conferences and other meetings on matters relating to crop protection and to publish and distribute the proceedings of these meetings;

to identify short- and long-term requirements for research and development in the field of crop protection;

to act as a liaison agency and to collaborate with other organisations with similar objectives.

Further information about The BCPC, its organisation and its work can be obtained from:

The Administrative Secretary
The British Crop Protection Council
20 Bridport Road,
Thornton Heath,
Surrey CR4 7QG, UK

1987 British Crop Protection Conference Weeds

Organising Committee:

Chairman	Mr D. J. Higgons
Members	Dr J. T. Braunholtz
	Dr K. J. Brent
	Dr Q. A. Geering
	Mr E. Lester
	Mr R. F. Norman
	Mr R. T. R. Pierce
	Dr D. Rudd-Jones
	Mr R. H. Tysoe
	Mr D. Tyson
Conference Secretary	Mrs R. A. Bishop
General Manager	Mr B. J. T. Baldwin

Programme Committee:

Chairman	Mr D. Tyson
Vice-Chairmen	Mr M. F. Askew
	Dr D. Atkinson
	Dr R. G. Turner
Exhibition Officer	Mr R. H. Tysoe
Public Relations Officer	Mr R. T. R. Pierce
Committee Secretary	Mrs D. Baxter
Session Organisers	Mr J. P. Byrne
	Mr R. W. Clare
	Dr D. J. Cole
	Dr R. Cousens
	Dr A. D. Dodge
	Mr D. M. Farrant
	Mr W. Griffiths
	Mr D. Hill
	Dr K. S. Killham
	Ms C. M. Knott
	Mr H. M. Lawson
	Dr P. J. Lutman
	Mr M. May
	Ms P. H. Moult
	Dr K. E. Pallett
	Dr P. D. Putwain
	Dr N. W. Sotherton
	Dr A. Walker
	Mr G. C. White

ABBREVIATIONS

acid equivalent	a.e.
active ingredient	a.i.
aqueous concentrate	a.c.
boiling point	b.p.
British Standards Institution	BSI
centimetre(s)	cm
concentration	concn
concentration × time product	ct
concentration required to kill 50% of test organisms	LC50
correlation coefficient	*r*
cultivar	cv.
cultivars	cvs.
day(s)	d
days after treatment	DAT
degrees Celsius (centigrade)	°C
dose required to kill 50% of test organisms	LD50
dry matter	d.m.
Edition	Edn
Editor	Ed.
Editors	Eds
emulsifiable concentrate	e.c.
freezing point	f.p.
gas chromatography-mass spectrometry	g.c.m.s.
gas-liquid chromatography	g.l.c.
gram(s)	g
growth stage	GS
hectare(s)	ha
high performance (or pressure) liquid chromatography	h.p.l.c.
hour	h
infrared	i.r.
International Standardisation Organisation	ISO
Kelvin	K
kilogram(s)	kg
least significant difference	L.S.D.
litre(s)	litre
litres per hectare	l/ha
mass	*m*
mass per mass	*m*/*m*
mass per volume	*m*/*V*
mass spectrometry	m.s.
maximum	max.
melting point	m.p.
metre(s)	m
milligram(s)	mg
millilitre(s)	ml
millimetre(s)	mm
minimum	min.
minute (time unit)	min
molar concentration	M

nuclear magnetic resonance	nmr
number average diameter	n.a.d.
number median diameter	n.m.d.
organic matter	o.m.
page	p.
pages	pp.
parts per million by volume	mg/l
parts per million by weight	mg/kg
pascal	Pa
percentage	%
post-emergence	post-em.
power take off	p.t.o.
pre-emergence	pre-em.
probability (statistical)	*P*
relative humidity	r.h.
revolutions per minute	rev./min.
second (time unit)	s
standard error	S.E.
standard error of means	S.E.M.
soluble powder	s.p.
species (singular)	sp.
species (plural)	spp.
square metre	m^2
subspecies	ssp.
surface mean diameter	s.m.d.
suspension concentrate	s.c.
temperature	temp.
thin-layer chromatography	t.l.c.
tonne(s)	t
ultraviolet	u.v.
vapour pressure	v.p.
variety (wild plant use)	var.
volume	*V*
volume median diameter of drop spray	v.a.d.
weight	wt
weight by volume (mass by volume is more correct)	wt/*V* (m*V*/)
weight by weight (mass by mass is more correct)	wt/wt (*m*/*m*)
wettable powder	w.p.
approximately	≃
less than	<
more than	>
not less than	≮
not more than	≯
Multiplying symbols—	Prefixes
mega ($\times 10^{6}$)	M
kilo ($\times 10^{3}$)	k
milli ($\times 10^{-3}$)	m
micro ($\times 10^{-6}$)	μ
nano ($\times 10^{-9}$)	n
pico ($\times 10^{-12}$)	p

SESSION 8A

WEED CONTROL IN PASTURE, UPLAND GRASS AND AGRO-FORESTRY

SESSION ORGANISER MR D. M. HILL

POSTERS 8A-1 to 8A-10

FLUROXYPYR : BROAD-LEAVED WEED CONTROL IN GRASSLAND

A.R. THOMPSON

Dow Agriculture, Latchmore Court, Brand Street, Hitchin, Herts SG5 1HZ

ABSTRACT

Fluroxypyr was examined in a series of trials from 1984-1987 for the control of broad-leaved weeds in grassland. Trials in new leys showed good control of Stellaria media at rates of 100-200g a.i./ha. Results in short-term leys and permanent pasture showed excellent control of Rumex spp. from applications of 300-400g a.i./ha and superior to standards. Yield trials demonstrated the significant adverse effect of Rumex spp. on the yield of grass dry matter. Results show effective control of Urtica dioica when 400g a.i./ha were applied pre-flowering. Crop tolerance trials showed fluroxypyr to be completely selective to a wide range of grass species.

INTRODUCTION

Broad-leaved weeds can have significant effects on the yield and quality of grass. In newly sown leys it has been shown that Stellaria media densities of 25 plants/m^2 can reduce ryegrass ground cover by half and eliminate clover populations completely. (Hagger et al 1985).

In short-term leys the most important weeds are Rumex spp. It has been shown that for every 1% Rumex spp. ground cover there is a 1% reduction in grass yield (Courtney, 1985). Currently there are 492,000 ha infested with Rumex spp. in the United Kingdom (Farmstat 1986).

In permanent pasture the important weeds are Urtica dioica, Rumex spp. and Cirsium spp. These weeds all reduce the quality and yield of grass. In addition broad-leaved weeds can lead to an overall reduction in grass quality which can require more frequent re-seeding.

Fluroxypyr was first introduced into the United Kingdom in 1984, as a 200g a.i./litre formulation of the 1-methyl heptyl ester, for the control of broad-leaved weeds in cereals (Thompson, 1985). It is rapidly absorbed and translocated inducing characteristic auxin type responses within a few hours of application (Sanders et al 1985). In cereals it has shown excellent control of Galium aparine and a range of other broad-leaved weeds including Bilderdykia convolvulus, Stellaria media, Galeopsis tetrahit and Myosotis arvensis (Paul et al 1985).

This paper reviews the efficacy of fluroxypyr for broad-leaved weed control in grassland particularly Rumex spp., U. dioica and S. media. Trials taken to yield demonstrate the effect of Rumex spp. on grass yields and the corresponding increase in grass yields after the use of fluroxypyr.

METHODS AND MATERIALS

During 1986 three trials were established to evaluate fluroxypyr for the control of Rumex spp. in grassland (series A-Table 1). Trials were of a randomised block design with each treatment replicated three times. Treatments were applied in 300 l/ha of water at 2 kPa. The Equipment used was a modified Oxford Precision sprayer. Plot size 2m x 10m. Weed control was assessed visually on a 0-100% scale. Application details are the same for all the trials unless otherwise stated.

A further programme of three trials was carried out in 1986 (series B-Table 1). The objective of this programme was threefold:
(i) To compare fluroxypyr with existing herbicides for the control of Rumex spp. in grassland.
(ii) To assess the long-term control of Rumex spp. in grassland.
(iii) To determine the effect of Rumex spp. on the yield of grass.

Treatments were applied in 200 l/ha of water at 2.5 kPa using a Van der Weij sprayer. The plot size varied depending on the type of grass cutter used. Weed control was assessed by % ground cover and the number of Rumex spp. per m^2. Plots were harvested using a grass cutter, either Agria or Haldrup.

2 trials were established to evaluate fluroxypyr for the control of U. dioica (series C-Table 1).

Trials were established to assess the control of S. media in newly sown leys in autumn (series D-Table 1) and spring (series E-Table 1).

The selectivity of fluroxypyr was evaluated in a weed free site in permanent pasture (series F-Table 1). Trial design was a randomised block with 6 replicates and a plot size of 2m x 10m. Crop scorch was assessed on a 0-10 scale where 0=No effect. The yield was determined by cutting a 1.0m x 10.0m swath through each plot using a cutter bar mounted on a Howard dragon cultivator. Fresh weight yields for each plot were taken and a subsample dried to 0% moisture to determine the dry weight yield.

Grass species were tested for tolerance to fluroxypyr applied in autumn or spring (1984/85) by Agrisearch Field Development Ltd (series G-Table 1). The site was drilled with parallel strips 1.25m wide and chemical treatment applied at right angles to the grass strips 2.0m wide. Treatments were applied using a Van der Weij sprayer. Application was made in 250 l/ha water. Assessments were made for vigour reduction and scorch.

For all trials a 200g a.i./l formulation of 1-methyl heptyl ester of fluroxypyr was used.

Standards		
Triclopyr	240	g a.i./l
Triclopyr + dicamba + 2,4-D	65+85+200	g a.i./l
Benazolin/2,4-DB/MCPA	27+237+43	g a.i./l
Mecoprop	570	g a.i./l
Asulam	400	g a.i./l

TABLE 1

Site Details

Trial Series	Trial No.	Location	Weeds	Date of application	Size of weeds at application	Weeds per m² or % ground cover
A	1	Derbyshire	Rumex spp.	28.5.87	40cm	95%
	2	Ayrshire	"	2.7.86	40-50cm	75%
	3	Sussex	"	15.5.86	45cm early flower bud	75%
B	1	Avon	"	27.7.86	25cm across	25%
		"	"	28.8.86	20cm across	28%
	2	Cheshire	"	3.6.86	18cm high 25cm across	33%
		"	"	4.8.86	10cm high 25cm across	38%
	3	Dyfed	"	3.8.87	15-20cm high	39%
		"	"	2.10.86	10cm high	39%
C	1	Norfolk	U.dioica	29.5.86	125cm high early flower bud	50-75%
	2	Gloucester	"	30.6.86	150cm mature	75%
D	1	Hertfordshire	S.media	10.12.86	15cm high	7.5/m²
	2	Warwickshire	"	23.11.87	20cm high	20/m²
	3	Norfolk	"	19.11.86	10cm high	10/m²
E	1	Oxfordshire	"	15.6.87	20cm high 30cm diameter	10/m²
	2	Hertfordshire	"	17.6.87	5cm high	37/m²
F	1	Norfolk		28.5.86		
G	1	Derbyshire		31.10.84 24.4.85		

RESULTS

Fluroxypyr showed a dose response to the control of Rumex spp. (series A). 400g a.i./ha gave excellent control and superior to standard treatments (Table 2). The symptoms are initial stunting and twisting of the leaf stalk. This is followed by a curling and reddening of the leaves and finally death. The tap-roots were killed completely.

TABLE 2

% control of Rumex spp. 8 weeks (WAT), 12 weeks (WAT) and one year (YAT) after treatment. 3 trials U.K.

Assessment date		8 WAT			12 WAT			1 YAT			1 YAT
Trials		1	2	3	1	2	3	1	2	3	MEAN
Treatment	Rate g a.i./ha										
Fluroxypyr	200	91	64	75	95	98	88	85	84	77	82
	300	91	76	80	94	99	87	76	98	83	86
	400	98	84	88	95	100	95	90	98	93	94
Triclopyr	960	84	64	85	94	97	94	77	94	87	85
	1440	87	70	83	97	98	92	82	97	80	86
Triclopyr+ 2,4-D+ Dicamba	325+1000+425	97	100	80	100	100	88	95	91	78	88

Three trials were established in Avon, Cheshire and Aberstwyth (series B). Each site was treated at two application timings, mid-summer and autumn.

Table 3 shows the % control of Rumex spp. 6-8 weeks after application and one year after application at each site. At both times of application fluroxypyr at 400g a.i./ha gave excellent Rumex spp. control and was superior to the standard treatments.

Table 4 shows the yield of Rumex spp. and grass dry matter from these trials. Grass yield on the untreated plots (% ground cover of Rumex spp. 25-40%) was reduced between 33 and 40% compared to plots treated with fluroxypyr at 400g a.i./ha, where Rumex spp. control was almost complete.

TABLE 3

Comparison of herbicide treatments for the control of *Rumex* spp.

		% control 6-8 weeks (WAT) and 1 year (YAT) after treatment											
TRIALS		TRIAL 1				TRIAL 2				TRIAL 3			
APPLICATION DATE		27.7.86		28.8.86		3.6.86		4.8.86		3.8.86		2.10.86	
ASSESSMENT		6 WAT	1 YAT	6 WAT	1 YAT	6 WAT	1 YAT	6 WAT	1 YAT	8 WAT	1 YAT	8 WAT	1 YAT
TREATMENT	g a.i./ha												
Fluroxypyr	200	73	54	90	60	100	85	96	91	95	96	90	85
Fluroxypyr	400	100	80	100	87	100	98	96	96	99	99	90	84
Triclopyr	1440	100	59	100	80	100	90	94	88	59	78	92	71
Mecoprop	2400	100	64	100	73	100	93	71	93	72	83	86	85
Asulam	1600	87	60	73	64	100	90	100	96	97	88	27	66

TABLE 4

Comparison of herbicide treatments on the dry matter yield (Kg/ha) of *Rumex* spp. and grass

TRIAL		TRIAL 1		TRIAL 2				TRIAL 3			
APPLICATION DATE		29.7.86		3.6.86		4.8.86		3.8.86		2.10.86	
HARVEST DATE		11.9.86		28.5.87		28.5.87		6.7.87		6.7.87	
		GRASS	RUMEX SPP.	GRASS	RUMEX SPP.	GRASS	RUMEX SPP.	GRASS	RUMEX SPP.	GRASS	RUMEX SPP.
TREATMENT	g a.i./ha				Kg/ha						
Untreated		1543	1053	3729	1565	3729	1565	2855	1065	2855	1065
Fluroxypyr	200	2487	25.87	5125	90.8	5556	64.0	4817	56.0	4568	100.0
Fluroxypyr	400	2664	0	5514	16.1	5576	43.0	4499	2.0	4570	76.0
Triclopyr	1440	2647	6.96	5368	42.1	5611	98.0	4814	113.0	4287	181.0
Mecoprop	2400	2584	0	5486	43.8	5299	78.0	4616	16.0	4657	118.0
Asulam	1600	2246	1.04	5437	93.4	5340	35.0	4398	87.0	4364	7.0

2nd timing site 1 not harvested.

Fluroxypyr showed a dose response in the control of U. dioica (series C). When fluroxypyr was applied pre-flowering 400g a.i./ha gave good control in the season of application. However control is reduced if fluroxypyr is applied to mature U. dioica after flowering. Trial 2 (Table 5).

TABLE 5

% control of U. dioica 8 weeks (WAT), 24 weeks (WAT) and one year (YAT) after treatment. 2 trials U.K.

		% control				
Assessment date		8 WAT		24 WAT		1 YAT
Trials		1	2	1	2	* 2
Treatment	Rate g a.i./ha					
Fluroxypyr	200	100	62	80	24	37
	300	100	88	80	44	40
	400	100	91	100	44	48
Triclopyr	480	100	94	100	84	77
	960	100	97	100	88	87
Triclopyr+ 2,4-D+ Dicamba	195+600+255	100	91	100	73	67

* No data available site 1, 1 YAT

Fluroxypyr at 150-200g a.i./ha gave excellent control of S.media superior to standards (series D, Table 6 and series E, Table 7).

TABLE 6

% control of S. media 8 and 16 weeks after treatment (WAT) in the autumn. 3 trials U.K.

		% control				
Assessment date		8 WAT	16 WAT	8 WAT	16 WAT	8 WAT
Trials		1		2		3
Treatment	Rate g a.i./ha					
Fluroxypyr	100	70	68	68	87	100
	150	67	82	93	93	100
	200	77	90	98	100	100
Benazolin/2,4-DB/MCPA	219+1659+301	47	65	97	100	90
Mecoprop	2400	53	57	100	100	70

TABLE 7

% control of S. media 8 weeks after treatment (WAT) in spring

Trials Treatment	Rate g a.i./ha	% control (1)	(2)
Fluroxypyr	100	70	77
	150	100	97
	200	100	97
Benazolin/2,4-D/MCPA	219+1659+301	95	75
Mecoprop	2400	100	93

Crop tolerance

No crop effects and no reduction in dry matter were detected (series F, Table 8).

TABLE 8

Crop responses and yield data for fluroxypyr applications to permanent pasture

Treatment	Rate g a.i./ha	Scorch	d.m. mean yield $Kg/10m^2$
Untreated		0	0.355
Fluroxypyr	100	0	0.435
	200	0	0.458
	400	0	0.355

Fluroxypyr was applied at 200 and 400g a.i./ha to five species of grasses (series G, Table 9). No phytotoxic symptoms were observed following application in the autumn or spring.

TABLE 9

Crop tolerance - Growth stages at treatment

Grass species	Cultivar	Growth stages 31.10.84	24.4.85
Italian Ryegrass	RVP30	22	32
	Sabalan	22	32
	Augusta	24	32
Perennial Ryegrass	Frances	22	32
	Talbot	22	31
	Melle	24	31
	Meltra	21	30
Timothy	S48	21	30
	Erecta	21	32
Cocksfoot	Jesper	21	31
	S26	21	30
Meadow Fescues	215	22	30

DISCUSSION

Fluroxypyr has given excellent control of Rumex spp. in the trials. 6-8 weeks after application fluroxypyr gave good control at 200g a.i./ha and excellent control at 400g a.i./ha. One year after application 200g a.i./ha did not give acceptable control but 400 g a.i./ha gave excellent control at all timings and size of Rumex spp. Standard treatments showed less flexibility in the time of application and size of Rumex spp.

Yield trials demonstrated the significant effects of Rumex spp. on the yield of grass supporting the concept of an inverse relationship between Rumex spp. infestation levels and grass yield.

When fluroxypyr was applied pre-flowering to U. dioica 400g a.i./ha gave good control in the season of application. However control is reduced if fluroxypyr is applied to mature U. dioica after flowering. At the latter stage, triclopyr was the product of choice.

Fluroxypyr offers a new opportunity to control the major weeds in new and short-term leys.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help of Agrisearch Field Development Ltd and the Agricultural Development and Advisory Service as well as colleagues in Dow Agriculture field trials teams.

Fluroxypyr 200g a.i./l is marketed in the U.K. by Dow Agriculture as Starane* 2, a trademark of The Dow Chemical Company.

REFERENCES

Courtney, A.D. (1985) Impact and control of Docks in grassland. BCPC monograph 29 120-127.

Farmstat, (1986) Herbicide usage and age of grass. Farmstat 1985/86.

Hagger, R.J.; Standell, C.J.; Birnie, J.E. (1985) Occurrence impact and control of weeds in newly sown leys. BCPC Monograph 29 11-19.

Paul, J.A.; Sutton, P.B.; Skidmore, A.M.; Scorer, D.J. (1985) FF4014: a new broad spectrum cereal herbicide based on fluroxypyr. Proceedings 1985 British Crop Protection Conference-Weeds, 3 929-946.

Sanders, G.E.; Thompson, L.M.; Pallet, K.E. (1985) The influence of morphology of Galium aparine on the uptake and movement of clopyralid and fluroxypyr. Proceedings 1985 British Crop Protection Conference-Weeds, 1 419-426.

Thompson, A.R. (1985) A survey of the commercial usage of fluroxypyr herbicide. Aspects of Applied Biology 9 221-228.

CONTROL OF DOCK AND CREEPING THISTLE IN RYEGRASS AND RED FESCUE SWARDS

C.J. STANDELL

Department of Agricultural Sciences, University of Bristol, AFRC Institute of Arable Crops Research, Long Ashton Research Station, Bristol, BS18 9AF

ABSTRACT

Fluroxypyr and metsulfuron-methyl gave good control of broad-leaved dock (*Rumex obtusifolius*) when sprayed in August. With May application, neither herbicide produced as good control. Maximum effects were reached after 1 month with fluroxypyr and between 2 and 3 months after spraying with metsulfuron-methyl. The top dose of glufosinate applied in August gave prolonged control but caused up to two months damage to perennial ryegrass. There was little damage to ryegrass from fluroxypyr. Metsulfuron-methyl, at the two higher doses, gave a noticeable suppression of grass growth between 1 and 3 months after spraying.

Creeping thistle (*Cirsium arvense*) proved difficult to control. From the August application, only the highest dose of glufosinate gave as good control as the MCPA standard. However, this dose caused up to two months suppression of the red fescue (*Festuca rubra*) sward. Spraying in May gave better results, especially with metsulfuron-methyl and its mixture with chlorsulfuron. Neither affected the fescue sward.

INTRODUCTION

Creeping thistle (*Cirsium arvense*) is a serious, widespread weed of permanent grass in the U.K., infesting over 1 M ha (Peel & Hopkins 1980), mainly older, poorly grazed, low input swards (Forbes *et al*. 1980). Cultural control is slow, frequent topping rarely eradicating the weed, especially if land management remains unchanged. Reproduction is mainly vegetative via the extensive root system which reduces herbicide efficacy (Chancellor 1970). Complete kill is virtually impossible with a single herbicide application. MCPA is currently used as a standard herbicide for thistle control.

Dock (*Rumex obtusifolius*) is the main member of a group of weeds affecting over 0.6 M ha, predominantly higher-input dairy enterprises (Peel & Hopkins 1980). Docks are profuse seeders and, thus, prevention of seed formation is essential to halt spread. Asulam, a standard herbicide for dock control, often requires repeat applications for long-term control.

During evaluations of experimental herbicides for controlling these weeds, several promising chemicals have been discovered (Richardson *et al*. 1980, 1981, 1982, 1984). They have been examined further in this investigation.

MATERIALS AND METHODS

Experimental site and sowing details

In March 1983, the experimental site was ploughed, cultivated, rolled and fertilized (N:P_2O_5:K_2O, 80:40:40 kg/ha). Perennial ryegrass (cv Melle) and red fescue (cv Boreal) were sown (5 May 1983) in 1.5 x 35.0 m strips (seed rate 25 kg/ha) using an Oyjord drill with 14 coulters. There were four adjacent paired strips of the two grasses separated by 2 m discards, providing two replicates for each spraying date. Fertilizer was again applied, at the same rate, on 21 March 1984 and 19 April 1985. Each grass strip was divided into 20 plots (1.5 x 1.5 m) for herbicide treatments.

On 17 February 1983, seeds of dock and rhizome fragments of creeping thistle were placed in pots (10 cm) of sandy loam soil. The pots were kept in a heated glasshouse until the plants were transplanted into the field 11 days after drilling. Within each ryegrass plot, 2 dock plants were planted evenly spaced along the diagonal. This planting arrangement allows for unevenness of either spraying or drilling. The fescue plots were similarly planted with thistles.

Treatments

Seventeen herbicide treatments and three unsprayed controls (Table 1) were randomised across each pair of grasses. Treatments were applied by Oxford Precision Sprayer with 3 x 8002 Teejet nozzles (300 l/ha; 208 kPa) either on 12 August 1983, or 30 May 1984. Weather on both occasions was sunny, very light westerly wind, high cloud cover (6/8). Foliage was dry and no rain fell within 24 h.

TABLE 1

Herbicide treatments

Herbicide	Dose rates (kg a.i./ha)			Spray dates Aug 83	May 84
Acifluorfen	0.5	1.0	2.0	+	+
Fluroxypyr	0.25	0.5	1.0	+	+
Glufosinate	0.3	0.6	1.2	+	+
Metsulfuron-methyl	3.75g	7.5g	15.0g	+	+
Chlorsulfuron +)	7.5g+)	15.0g+)	22.5g+)	–	+
Metsulfuron-methyl)	2.5g)	5.0g)	7.5g)		
MBR 18337	0.1	0.2	0.4	+	–
Asulam	1.12			+	+
MCPA	1.7			+	+

Plots not sprayed until May 1984 were cut using a Haldrup plot harvester on 22 September 1983. Sprayed plots were cut on 26 October 1983, 75 days after spraying.

Assessments

At each spraying date, the docks and thistles on the unsprayed plots were assessed for height, plant overall diameter and leaf or stem number. The associated grass height was also recorded. Visual scores (0 = no green herbage to 9 = as unsprayed control) of herbicide damage were made at approximately 10 day intervals in 1983. After the May application, scores were made every ten days for one month and then monthly. Plots were finally assessed on 3 June 1985. The thistle plots were assessed only by noting which plots contained thistle plants. Some plots had been invaded by thistles from neighbouring plots making accurate scores difficult. At each assessment date, two people independently scored weed and crop growth and the means of both scores were recorded.

RESULTS

Stage of growth assessment

The mean size of all dock and thistle plants, on the unsprayed control plots, at the time of spraying are recorded in Table 2. Dock plants were approximately twice as high in May as in August but there was little difference in leaf number or overall diameter of the plants. In contrast, in May the thistles were half the height of those sprayed the previous year. Both grass swards were considerably taller when sprayed in May.

TABLE 2

Size of weeds and height of crop at spraying

	12 August 1983		30 May 1984	
	Dock	Thistle	Dock	Thistle
Height (cm)	14.7	60.0	32.3	31.3
Diameter (cm)	50.8	43.0	50.6	45.7
Leaf or stem no.	21.0	8.0	17.6	9.3
Crop height (cm)	9.8	13.2	18.5	40.7

Herbicide effects on docks

From the August treatments, several of the herbicides gave complete, prolonged weed control with no regrowth within two years (Table 3). Most of the treatments gave better control than asulam. Generally, May applications were less effective than those in August (Table 4), although metsulfuron-methyl alone and with chlorsulfuron gave excellent control for at least a year after application. With both asulam and metsulfuron-methyl, it was over two months before maximum effects were seen. Acifluorfen and MBR 18337 (omitted from the tables) had no effect on either weed.

TABLE 3

Visual score of herbicide effects on docks sprayed on 12 August 1983.

Treatment	Dose	Weeks after spraying				
	(kg a.i./ha)	1	4	9	34	95
Unsprayed control		9	9	9	9	9
Asulam	1.12	7	6	1.5	2	4
Fluroxypyr	0.25	7	6	1.5	2	4
"	0.5	7.5	1	0	0	2.5
"	1.0	5	0	0	0	0
Glufosinate	0.3	3	3	6.5	7	6
"	0.6	2	1	3.5	7.5	6
"	1.2	1.5	0.5	1	1	0.5
Metsulfuron-methyl	3.75g	7.5	4.5	2	0	0
"	7.5g	7.5	4.5	1.5	0	0
"	15.0g	8	5	1.5	0	0
l.s.d.		2.08	2.22	2.09	1.21	2.85

TABLE 4

Visual score of herbicide effects on docks sprayed on 30 May 1984.

Treatment	Dose (kg a.i./ha)	Weeks after spraying 1	4	13	53
Unsprayed control		9	9	9	9
Asulam	1.12	8	3.5	1	9
Fluroxypyr	0.25	5.5	1	0	8
"	0.5	5	0	0	8
"	1.0	4	0	0	6.5
Glufosinate	0.3	2	2	2	8
"	0.6	1.5	0.5	3.5	9
"	1.2	1	0.5	1.5	7.5
Metsulfuron-methyl	3.75g	7.5	7.5	3	3
"	7.5g	7.5	4.5	1	0
"	15.0g	8	5	0.5	0
Chlorsulfuron+	7.5g + 2.5g	8	6	3.5	1
Metsulfuron-methyl	15.0g + 5.0g	8	4	1	0
"	22.5g + 7.5g	7.5	4	1	0
l.s.d.		1.20	0.86	2.77	2.01

TABLE 5
Visual score of herbicide effects on perennial ryegrass

Treatment	Dose (kg a.i./ha)	Weeks after spraying on 12 August 1983: 1	4	9	30 May 1984: 1	4	13
Unsprayed control		9	9	9	9	9	9
Asulam	1.12	7.5	8	9	9	8.5	9
Fluroxypyr	0.25	8.5	8	9	8.5	7.5	7.5
"	0.5	9	7.5	8	9	9	8.5
"	1.0	8	7.5	8.5	9	8	9
Glufosinate	0.3	4	8.5	9	5.5	8.5	8
"	0.6	2.5	9	9	3	5.5	6
"	1.2	2.5	7	9	2	1.5	2.5
Metsulfuron-methyl	3.75g	7.5	7	8.5	9	7.5	6.5
"	7.5g	8.5	6	7.5	8.5	6	5
"	15.0g	7.5	4	7	9	6.5	5
Chlorsulfuron +	7.5g + 2.5g	-	-	-	9	7	6
Metsulfuron-methyl	15.0g + 5.0g	-	-	-	8.5	4.5	4.5
"	22.5g + 7.5g	-	-	-	9	4.5	5
l.s.d.		1.20	0.87	0.53	0.50	0.79	1.31

Herbicide effects on perennial ryegrass

Ryegrass was affected by all the chemicals to differing degrees (Table 5). Asulam and fluroxypyr were least damaging, causing only slight scorching. All the glufosinate treatments caused significant damage after seven days. Generally, this herbicide was the most damaging to ryegrass, maximum effects occurring between 1 and 4 weeks after spraying and being more severe and prolonged with the higher doses sprayed in May. Metsulfuron-methyl alone and in mixture with chlorsulfuron caused intermediate damage, taking a month or more for maximum effects to develop.

Herbicide effects on thistles

Of the August treatments only the highest dose of glufosinate gave complete control after two years (Table 6). Several other treatments, including the two higher doses of metsulfuron-methyl and the MCPA standard, showed complete control of thistles but only on one of the two replicate plots. The thistles, on these plots, were most likely to have spread from unaffected plants on neighbouring plots. There were more promising results from treatments sprayed in May. One year after treatment, there was no recovery from the top two doses of metsulfuron-methyl applied alone and with chlorsulfuron. The top dose of glufosinate also gave complete control. All other treatments, except the low dose of fluroxypyr and glufosinate, showed control of thistles but only on one replicate.

TABLE 6

Visual score of herbicide effects on thistles sprayed on 12 August 1983.

Treatment	Dose (kg a.i./ha)	Weeks after spraying 1	4	9	95
Unsprayed control		9	9	9	++
MCPA	1.7	6	2	1.5	+
Fluroxypyr	0.25	8.5	9	9	++
"	0.5	8	7.5	9	++
"	1.0	8.5	8	7.5	+
Glufosinate	0.3	2	2	2.5	++
"	0.6	2.5	2	2.5	++
"	1.2	1.5	1.5	1.5	-
Metsulfuron-methyl	3.75g	8.5	5.5	8	++
"	7.5g	9	7.5	6.4	+
"	15.0g	8	4.5	4.5	+
l.s.d.		0.92	1.86	2.43	

Thistles present on both replicates (++), one replicate (+) or absent (-)

TABLE 7

Visual score of herbicide effects on thistles sprayed on 30 May 1984.

Treatment	Dose (kg a.i./ha)	Weeks after spraying 1	4	13	53
Unsprayed control		9	9	9	9
MCPA	1.7	7.5	4	0	+
Fluroxypyr	0.25	9	9	8.5	++
"	0.5	9	8	6.5	+
"	1.0	8.5	5	4	+
Glufosinate	0.3	2.5	2.5	4.5	++
"	0.6	2.5	3	2.5	+
"	1.2	1	1	0.5	-
Metsulfuron-methyl	3.75g	7.5	5.5	1	+
"	7.5g	8	6	0	-
"	15.0g	8	3.5	0	-
Chlorsulfuron+	7.5g + 2.5g	8.5	5.5	1	+
Metsulfuron-methyl	15.0g + 5.0g	7	4.5	0	-
"	22.5g + 7.5g	9	6	0	-
l.s.d.		1.10	3.33	4.32	

Thistles present on both replicates (++), one replicate (+) or absent (-)

TABLE 8

Visual score of herbicide effects on red fescue

Treatment	Dose (kg a.i./ha)	Weeks after spraying on 12 August 1983 1	4	9	30 May 1984 1	4	13
Unsprayed control		9	9	9	9	9	9
MCPA	1.7	8	9	8	9	9	9
Fluroxypyr	0.25	9	9	9	9	9	9
"	0.5	8.5	9	9	9	9	9
"	1.0	9	9	8.5	9	9	9
Glufosinate	0.3	4	6	9	6	9	9
"	0.6	3.5	4.5	9	4	6.5	9
"	1.2	3.5	2.5	8.5	3	3	4.5
Metsulfuron-methyl	3.75g	8.5	9	9	9	9	9
"	7.5g	9	9	9	8.5	9	9
"	15.0g	8.5	8.5	9	9	8	9
Chlorsulfuron +	7.5 + 2.5g	-	-	-	9	9	9
Metsulfuron-methyl	15.0 + 5.0g	-	-	-	9	9	9
"	22.5 + 7.5g	-	-	-	9	9	9
l.s.d.		0.56	0.37	0.50	0.66	0.66	0.2

Herbicide effects on red fescue

Red fescue proved to be more tolerant of herbicides than ryegrass and was unaffected by all the chemicals apart from glufosinate (Table 8). All doses of glufosinate sprayed in August caused severe damage but there was full recovery within two months. However, when sprayed in May, although the effects were less severe, recovery took longer than three months with the highest dose.

DISCUSSION

Fluroxypyr, metsulfuron-methyl and the highest dose of glufosinate were more effective on docks than asulam (a recommended herbicide) when sprayed in August. Control was complete and there were no signs of regrowth two years later. Only metsulfuron-methyl alone, or in the mixture with chlorsulfuron, gave prolonged control of docks when applied in May with no regrowth one year after application. In August, the mean height of dock plants on the unsprayed plots was 14.7 cm, whereas in May it was 32.3 cm, suggesting that the herbicides controlled docks better when plants were small at time of spraying.

As expected, thistles proved more difficult to eradicate and only the highest rate of glufosinate sprayed in August had any prolonged effect, no regrowth occuring within two years. Treatments containing higher doses of metsulfuron-methyl, applied the following May, showed potential with no regrowth one year after application. There was also no regrowth within a year from the highest dose of glufosinate. Thistles sprayed in May were half the size of those sprayed in August, and this might explain the slightly better control found with the May application.

Of the two crop species, red fescue was more tolerant of the herbicides. Only glufosinate caused very severe scorching within one week of spraying. However, plots recovered fully within two months after the August spraying and, although the effects were initially less severe following the May application, it was three months before the lower dose plots recovered. Ryegrass was similarly affected by glufosinate at both times of appliction. Unlike red fescue, the ryegrass was also affected by treatments containing metsulfuron-methyl. Although damage was less severe than from glufosinate, it took between one and three months for maximum effects to show.

Fluroxypyr, metsulfuron-methyl alone and with chlorsulfuron and possibly glufosinate showed promise for complete and prolonged control of both R. obtusifolius and C. arvense in grassland. There appears to be reasonable crop safety but further effort is needed to optimise doses and reduce damage. Stage of growth and time of application, however, are important factors which need further investigation.

REFERENCES

Chancellor, R.J. (1970) Biological background to the control of three perennial broad-leaved weeds. Proceedings 10th British Weed Control Conference, 3, 1114-1120.

Forbes, T.J., Dibb, C., Green, J.O., Hopkins, A., Peel, S. (1980) Factors affecting the productivity of permanent grassland. Hurley: Joint Permanent Pasture Group. 141 pp.

Peel, S. Hopkins, A. (1980) The incidence of weeds in grassland. Proceedings 1980 British Crop Protection Conference - Weeds, 3, 877-890.

Richardson, W.G., West, T.M., Parker, C. (1980) The activity and post-emergence selectivity of some recently developed herbicides: R 40244, DPX 4189, acifluorfen, ARD 34/02 (NP 55) and PP 009. Technical Report Agricultural Research Council Weed Research Organization, 61, pp. 57.

Richardson, W.G., West, T.M., Parker, C. (1981) The activity and post-emergence selectivity of some recently developed herbicides: SSH-41, MB 30775, AC 213087, AC 222293 and Dowco 433. Technical Report Agricultural Research Council Weed Research Organization, 63, pp. 60.

Richardson, W.G., West, T.M., Parker, C. (1982) The activity and post-emergence selectivity of some recently developed herbicides: trifopsime, glufosinate, RH 8817, MBR 18337 and NC 20484. Technical Report Agricultural Research Council Weed Research Organization, 67, pp. 5.

Richardson, W.G., West, T.M., White, G.P. (1984) The activity and selectivity of some recently developed herbicides: AC 252214, DPX-T6376 and chlorazifop. Technical Report Agricultural Research Council Weed Research Organization, 74, pp. 33.

THE ACTIVITY OF NEW HERBICIDES ON BRACKEN AND GRASS SPECIES

T.M. WEST

Institute of Arable Crops Research, Long Ashton Research Station, Department of Agricultural Sciences, University of Bristol, Long Ashton, Bristol, BS18 9AF, U.K.

W.G. RICHARDSON

20, Hill Rise, Woodstock, Oxfordshire, U.K.

ABSTRACT

In two outdoor pot experiments, ten herbicides, including the new sulphonyl-urea herbicides DPX-L 5300 and triasulfuron, were examined for their potential to control bracken (*Pteridium aquilinum*). In a separate outdoor pot experiment, seedling grasses were included in a trial investigating post-emergence selectivity of DPX-L 5300 and triasulfuron.

Asulam gave effective control of bracken in both experiments. Five sulphonyl-urea herbicides were active at doses ranging from 2.5-80 g a.i./ha. DPX-L 5300, triasulfuron, chlorsulfuron and metsulfuron-methyl all severely reduced or prevented regeneration the year after treatment. Thiameturon-methyl also gave good suppression of regrowth but was less effective in reducing the amount of viable rhizome. Imazapyr was highly active. Fluroxypyr, triclopyr and SMY 1500 were ineffective.

Four seedling grasses, *Lolium perenne*, *Festuca rubra*, *Agrostis stolonifera* and *Poa annua*, showed appreciable tolerance to DPX-L 5300; *L. perenne* was more sensitive than the other grass species to triasulfuron.

The potential for control of bracken by these relatively new herbicides is discussed.

INTRODUCTION

There are many recent reports on the rapid spread of bracken (*Pteridium aquilinum*) (Taylor, 1986). This particularly applies to forestry and hill farming areas of the U.K., where it has shown encroachment rates of 1-3% per annum, causing losses of large areas of useful land. It is also a health hazard to grazing animals (Evans, W.C., 1986) and possibly to humans (Galpin & Smith, 1986, Evans, I.A., 1976).

Herbicides can be employed as part of a programme for bracken clearance. Asulam has been used against bracken for twenty years in the U.K. and achieves good control, but can damage useful grass species (Soper, 1970). Therefore, a herbicide is required that would give long term control of bracken, while causing less damage to indigenous grasses. More recent work, involving pot and field experiments, has shown that the sulphonyl-urea herbicides chlorsulfuron and metsulfuron-methyl are active on bracken (West & Richardson, 1985, Oswald *et al*, 1986).

New herbicide treatments for bracken were evaluated each year in pot experiments at the Weed Research Organization (W.R.O.) up to 1985 and subsequently by the Weed Research Division, L.A.R.S. This paper presents data from two experiments in which several herbicides, including the newer sulphonyl ureas, were examined. Information regarding herbicide activity on grass species from selectivity screening trials at L.A.R.S. is also included.

MATERIALS AND METHODS

Bracken experiments

Plant raising

One year before treatment, rhizome fragments with viable buds were collected from a natural population growing in Shotover Park, near Oxford. These were planted 8 cm deep in 25 cm pots containing a soil/peat/sand mixture (4:1:1) plus added base fertilizer. Pots were kept outdoors and irrigated as necessary using trickle irrigation pipes. Pots from experiments 1 and 2 were transported from W.R.O. to L.A.R.S. in March, 1986. During the winters at W.R.O., they were surrounded with straw bales for protection from frost, while, at L.A.R.S., they were plunged into ashes.

Herbicide treatments

The formulations used were as follows: chlorsulfuron 20% a.i. S.G., metsulfuron-methyl 70% a.i. W.G., thiameturon-methyl 75% a.i. S.G., DPX-L 5300 75% a.i. S.G., triasulfuron 75% a.i. W.G., imazapyr 250 g a.i./l liquid conc; asulam 400 ga.i./l. a.c.; SMY 1500 60% a.i. W.P., fluroxypyr 200 ga.e./l E.C., triclopyr 240 g a.e./l E.C. The treatments (Tables 1 and 2) were applied using a laboratory track sprayer fitted with a TeeJet No. 8001 at a pressure of 210 kPa and giving a volume rate of 208 l/ha. Surfactant (Agral 90) was added to all spray solutions at a rate of 0.25% v/v. Growth stages at spraying for experiment 1 were: 8-18 fronds/pot, 45-80 cm high, vigorous rhizome system, and, experiment 2: 6-10 fronds/pot, 45-60 cm high, vigorous rhizome system. Pots were kept under cover for twenty-four hours after spraying. Prior to removal outdoors, they were watered overhead using a rose to simulate heavy rainfall. Although the foliage covered most of the pot, a small amount of herbicide may have been washed off onto the soil. Treated plants were then returned outdoors and set out in three randomized blocks.

Assessments

One year after treatment, the vigour and number of surviving fronds per pot were recorded, then cut off at soil level and the fresh weight recorded. Vigour scores of frond regrowth were based on a 0-7 scale, where 0 = complete kill and 7 = as control (West & Richardson, 1980).

After removal of the soil, a score of the quantity of viable rhizome remaining was recorded. This was based on a 0-5 scale, where 0 = no viable rhizome, 1= 10% viable rhizome, 5 = 90% viable rhizome, compared with untreated controls.

Post-emergence selectivity test on grass species

The experimental details are described in Richardson & West, 1986. Plants were raised outdoors in 9 cm plastic pots in a silt loam with 15% v/v added sand. Treatments were applied (Table 3) at the 2-4 leaf stage using a laboratory track sprayer fitted with a TeeJet No. 80015, giving a volume rate of 312 l/ha at a pressure of 210 kPa. Assessments of plant vigour, based on a 0 - 7 scale, were made 3-4 weeks after treatment.

RESULTS

Effects on bracken - experiments 1 and 2

The standard asulam treatment was very effective in both experiments (Tables 1 and 2), resulting in little or no frond regrowth the year after spraying and appreciable reductions of viable rhizome. Effective treatments were also found from the sulphonyl-urea herbicides chlorsulfuron, metsulfuron-methyl, DPX-L 5300 and triasulfuron, and the imidazolinone herbicide imazapyr.

TABLE 1

Experiment 1: The effect of various herbicides applied 24 July, 1985, on bracken, assessed 20 August, 1986.

Herbicide	Dose (g a.i./ha)	Fronds Number[a]	Fronds fresh wt.[a]	Vigour Score fronds[b]	Vigour Score rhizome[c]
Chlorsulfuron	7.5	7	1	0.8	1.0
	15	0	0	0	0.3
Metsulfuron-methyl	5	0	0	0	0.3
	10	0	0	0	0
Chlorsulfuron	7.5 + 5	7	2	1.0	0.3
+	7.5 + 10	0	0	0	0.3
Metsulfuron-methyl	15 + 5	0	0	0	0
	15 + 10	3	1	0.7	0.3
Thiameturon-methyl	75	10	8	1.3	3.0
Imazapyr	500	0	0	0	0
	1000	0	0	0	0
SMY 1500	1500	100	81	6.7	5.0
Fluroxypyr	750	86	126	7.0	5.0
Triclopyr	3000	90	97	7.0	5.0
Asulam	2000	7	3	0.7	1.0
Untreated	-	100	100		
Actual value		(10)	(143g)	7.0	5.0
SE ±		9.1%	12.9%	0.40	0.26

[a] results expressed as % of untreated controls.
[b] 0-7 score 0 = dead, 7 = healthy.
[c] 0.5 score 0 = no viable rhizome, 1 = 10%, 5 = 90%

Chlorsulfuron and metsulfuron-methyl, either alone or in mixture, had negligible effects on the foliage in the year of spraying but severely reduced or prevented frond regrowth the following year giving substantial reductions of viable rhizome. Only a few chlorotic, deformed fronds regrew from chlorsulfuron at 7.5 g/ha a.i. in experiment 1 and none in experiment 2. Chlorsulfuron at 15 g/ha a.i. and metsulfuron-methyl at 5 and 10 g a.i./ha prevented regrowth, while 2.5 ga.i./ha metsulfuron-methyl in experiment 2 reduced frond regrowth fresh weights by 75%. Various mixtures of chlorsulfuron with metsulfuron-methyl reduced frond regrowth fresh weights by 80-100%.

DPX-L 5300 and triasulfuron, both at 40 and 80 g/ha a.i., prevented regeneration of fronds in the year after treatment and reduced viable rhizome by 94-100%.

Thiameturon-methyl, at 25 and 75 g/ha a.i., caused considerable reductions in frond regrowth but much of the remaining rhizome still appeared viable.

Imazapyr was very active in both experiments; 250, 500 and 1000 ga.i./ha a.i. prevented frond regrowth and there was no viable rhizome remaining.

SMY 1500 was ineffective, while triclopyr and fluroxypyr caused epinasty of fronds initially but there was healthy regeneration the following year.

TABLE 2

Experiment 2: The effect of various herbicides applied 14 July, 1986, on bracken, assessed 17 August, 1987.

Herbicide	Dose (g a.i./ha)	Fronds Number[a]	Fronds fresh wt.[a]	Vigour Score fronds[b]	Vigour Score rhizome[c]
DPX-L 5300	40	0	0	0	0
	80	0	0	0	0.3
Triasulfuron	40	0	0	0	0
"	80	0	0	0	0.3
Chlorsulfuron	7.5	0	0	0	0
Metsulfuron-methyl	2.5	51	14	1.7	1.0
Thiameturon-methyl	25	32	19	3.0	1.3
Chlorsulfuron + Metsulfuron-methyl	7.5 + 2.5	32	14	1.7	0.7
Thiameturon-methyl +Metsulfuron-methyl	25 + 2.5	51	17	2.0	1.3
Imazapyr	250	0	0	0	0
	500	0	0	0	0
Asulam	2000	0	0	0	0.3
Untreated	-	100	100		
Actual value		(5.3)	(120g)	7.0	5.0
SE±		26.0%	15.4%	1.06	0.68

[a,b,c] See Table 1

Post-emergence selectivity test (1986) - experiment 3

DPX-L 5300 at 5 and 20 g/ha a.i. caused very little or no damage (Table 3), while, at 80 g a.i./ha, all four grass species recovered vigorously after early suppression. There were only slight effects from triasulfuron at 2 g a.i./ha but, at 10 g a.i./ha, perennial ryegrass was sensitive, whereas the other species recovered vigorously. Considerable vigour reductions were caused by 50 g a.i./ha to all grass species tested.

TABLE 3

Experiment 3: Response of grass species to herbicides applied July 1986.

(Vigour score as % of untreated controls.)

Herbicide	Dose (g a.i./ha)	Perennial ryegrass (L. perenne)	Red fescue (F.rubra)	Creeping bent (A.stolonifera)	Annual meadow grass (P.annua)
DPX-L 5300	5	86	100	100	100
	20	71	93	100	100
	80	50	50	64	86
Triasulfuron (CGA 131036)	2	71	86	79	100
	10	14	64	64	64
	50	14	43	43	43
Untreated Actual value	-	100 (7)	100 (7)	100 (7)	100 (7)

DISCUSSION

The results of these preliminary pot experiments have highlighted alternative potential treatments for bracken control.

DPX-L 5300 and triasulfuron are new sulphonyl-urea herbicides being developed for broad-leaved weed control in cereals (Ferguson et al, 1985, Amrein and Gerber, 1985). In pot experiments, both have shown exceptional activity on bracken, although at higher than recommended doses. In the post-emergence selectivity trial, DPX-L 5300 caused little damage to various grass species, the tolerance of red fescue (F. rubra) and perennial ryegrass (L. perenne) being of special interest. With the triasulfuron, perennial ryegrass was more sensitive than the other grass species. For both these herbicides, lower rates than employed here need investigating to determine doses for bracken susceptibility and tolerance of pasture grasses.

Another sulphonyl-urea, thiameturon-methyl, also gave useful suppression of bracken regrowth and, although it appears the least active of those tested, its short soil persistence may make it a useful candidate for use in mixtures.

Chlorsulfuron, the first sulphonyl-urea found to be active against bracken (West & Richardson, 1985) again proved an effective treatment at doses which would give reasonable selectivity to grass species (Oswald et al, 1986). Metsulfuron-methyl, also a successful treatment in pots was less effective in field trials than chlorsulfuron (Oswald et al, 1985) and, as a single treatment, would probably require doses damaging to grasses. However, mixtures of chlorsulfuron with metsulfuron-methyl are also effective and doses required for control may be low enough to overcome unacceptable grass damage (Oswald et al., 1985).

Of the other herbicides tested, only imazapyr proved to be effective and doses below 250 g/ha need to be evaluated. This herbicide is recommended for total weed control but may have uses in forestry.

All the sulphonyl-urea herbicides tested showed potential, to a greater or lesser degree, for the control of bracken, particularly in hill pasture or amenity grass areas. DPX-L 5300 appears the most promising since it not only prevented fronds regrowing but seems the least damaging to grass species; also, it has very short soil persistence (Ferguson et al, 1985), perhaps making it a more environmentally acceptable treatment.

These results are from only two years' experimentation and further investigations in both pot and field trials are esssential to confirm the promise of these herbicides.

ACKNOWLEDGEMENTS

Thanks are due to the manufacturers for the supply of herbicides used in these experiments.

REFERENCES

Amrein, J., Gerber, H.R. (1985) CGA 131036: a new herbicide for broad leaved weed control in cereals. Proceedings British Crop Protection Conference - Weeds, 1, 55-62.

Evans, I.A. (1976) Relationship between bracken and cancer. Botanical Journal of the Linnean Society, 73, 105-112.

Evans, W.C. (1986) The acute diseases caused by bracken in animals. In: Bracken: Ecology, Land Use and Control Technology. Smith, R.T. and Taylor, J.A. (Eds.), Carnforth, Parthenon Press, pp. 121-132.

Ferguson, D.T., Schehl, S.E., Hageman, L.M., Lepone, G.E., Carraro, G.A. (1985) DPX-L 5300 - a new cereal herbicides. Proceedings British Crop Protection Conference - Weeds, 1, 43-48.

Galpin, O.P., Smith, R.M.M. (1986) Bracken, stomach cancer and water supplies: is there a link? In: Bracken: Ecology, Land Use and Control Technology. Smith, R.T. and Taylor, J.A. (Eds.), Carnforth, Parthenon Press, pp. 121-132.

Oswald, A.K., Richardson, W.G., Flint, C.E. (1985) The effects of sulphonyl-urea herbicides on Pteridium aquilinum (bracken) in hill pasture. Proceedings British Crop Protection Conference - Weeds, 2, 779-785.

Oswald, A.K., Richardson, W.G., West, T.M. (1986) The potential control of bracken by sulphonyl-urea herbicides. In: Bracken: Ecology , Land Use and Control Technology. Smith, R.T. and Taylor, J.A. (Eds.), Carnforth, Parthenon Press, pp. 431-440.

Richardson, W.G., West, T.M. The activity and post-emergence selectivity of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259 and DPX-M 6316. Technical Report Agricultural and Food Research Council, LARS, Weed Research Division, 1986, No. 92, pp. 42.

Soper, D. (1970) The tolerance of pasture grasses to asulam. Proceedings 10th British Weed Control Conference, pp.465-475.

Taylor, J.A. (1986) The bracken problem: a local hazard and global issue. In: Bracken: Ecology , Land Use and Control Technology. Smith, R.T. and Taylor, J.A. (Eds.), Carnforth, Parthenon Press, pp. 21-42.

West, T.M., Richardson, W.G. (1980) Response of established perennial weeds and Solanum tuberosum to various herbicide treatments. Internal Report Agricultural Research Council, Weed Research Organization, 140.

West, T.M., Richardson, W.G. (1985) Response of bracken (Pteridium aquilinum) in pots to various herbicide treatments. Tests of Agrochemicals and Cultivars, (Annals of Applied Biology 106, Supplement) No. 6, pp. 108-109.

THE CONTROL OF BRACKEN WITH SULPHONYL-UREA HERBICIDES

B O'CONNOR

Agricultural Development and Advisory Service, MAFF, St Mary's Manor, North Bar Within, Beverley, North Humberside HU17 8DN

D E FLINT

Agricultural Development and Advisory Service, MAFF, 78/81 Basingstoke Road, Reading RG2 OEF

M AQUILINA

Agricultural Development and Advisory Service, MAFF, Staplake Mount, Starcross, Exeter EX6 8PE

ABSTRACT

In experiment A, sulphonyl-urea herbicides were applied at early and full frond emergence at four sites. In experiment B, sulphonyl-urea herbicides were applied when the bracken was senescing as well as at early and full frond emergence at five sites. The mixture of Chlorsulfuron (C) + metsulfuron-methyl (MM) was more effective than the metsulfuron methyl alone. C + MM was effective in controlling bracken at all timings, the best treatment which was comparable with the standard Asulam being the higher rate applied at full frond emergence. The sulphonyl-ureas did not adversely affect grass growth whereas on occasions the asulam did. This work confirms the earlier promise of the sulphonyl-ureas in work done by (Oswald et al. 1985). The sulphonyl-ureas are cost effective herbicides which makes them all the more interesting. Further long term work needs to be done to provide more data on rates and timing.

INTRODUCTION

There is no precise record of the total area of bracken in the UK; further, the rate of spread varies in different parts of the country. (Taylor 1985) presents estimates of some of these statistics. Whilst the area of bracken is increasing it appears that the area being controlled is falling. According to (Mackay 1984) the area of grant aided bracken control in Scotland reached a peak of 8000 ha in 1952 declining to 200 ha by 1970. The introduction of asulam in 1972 gave an immediate increase to 3500 ha in 1974 but this fell to 1200-1400 ha in the early 1980s. Such figures for the rest of the UK are not readily extractible.

Today the main means of bracken control is with the herbicide asulam. The main reason for the fall off in bracken control is the high cost of application. One application costs approximately £85/ha which is a considerable expense in low output hill areas. Spraying with asulam has given good control but not eradication (Martin 1976, Veerasekaran et al. 1976, Williams, Fraser 1979). Follow-up treatments are required for long term bracken control. A number of grasses associated with bracken have been shown to be susceptible to asulam (Soper 1970, Davies 1979). To reverse the decline in the area of bracken controlled either a less expensive herbicide needs to be found, or the rate of grant aid needs to be increased. (Oswald et al. 1985) reported on the effectiveness of the sulphonyl-ureas chlorsulfuron (C) and metsulfuron methyl (MM) either alone or together (C + MM) in controlling bracken. Consequently in 1984 the Agricultural Development and Advisory Service set up an experiment (A) at four sites to investigate the efficacy of these two products applied alone and in mixture at early and full frond emergence. Asulam was applied as a control at full frond emergence. Effects on the number of fronds were measured for three years following treatment. Effects on the height of bracken was measured at three sites. The effect on grass d.m. yield was recorded at one site and reported previously (Oswald et al. 1985).

In 1985 another trial series (B) was established on a further five sites. The treatments in this series differed from the one started in 1984: metsulfuron-methyl on its own was no longer included and an additional spray timing was added when the bracken is senescing. Effects on the number of fronds has now been recorded for two years following treatment. Effects on the height of the bracken was recorded at four sites and effects on grass height and sward composition was recorded at one site but not recorded in this paper.

MATERIALS AND METHODS

Details of all the expeimental sites are shown in Tables 1, 2, 3 and 4.

In Experiment A, treatments (Tables 1 & 3) were applied at early (Timing 1) and full frond emergence (Timing 2) at sites 1-3 and at full frond emergence only at site 4 in 1984. The early frond emergence treatment in experiment 4 was not applied until 1985.

In Experiment B, treatments (Tables 2 and 4) were applied at three timings: early and full frond emergence and when the bracken was senescing (Timing 3). The early frond emergence spray timing at site 9 was not applied. In both trials each treatment was replicated three times in a randomised block design in plots 3 m x 5 m (sites 1 and 2), 2.5 m x 10 m (site 3), 3 m x 10 m (sites 4 and 9) and 3 m x 7 m (sites 5, 6, 7, 8). An Oxford Precision Sprayer was used fitted with Teejets No 8002 giving a volume of 200 l/ha at a pressure of 200 kPa. 'Agral' as a 0.25% v/v solution was added to all the sulphonyl-urea treatments and as a 0.1% v/v solution to the asulam treatment. All vegetation was dry and no rain fell during any of the applications.

Two 1 m x 1 m fixed quadrats in the centre of each plot were used each year to record the number of bracken fronds.

The SEDs quoted are for the comparison of the untreated control with any one treatment.

RESULTS

Experiment A: Effects on the number of bracken fronds

Results for the first year after treatment were reported by (Oswald et al. 1985).

In the second year after treatment at sites 1, 3 and 4 (Table 5) the asulam and C + MM sprays gave better results than the MM treatments. At sites 1 and 4 C + MM applied at timing 2 gave better results than when applied at timing 1. At site 3 there was little difference in control at the two timings. At site 2 only the asulam treatment gave acceptable results.

In the third year after treatment (Table 6) apart from the timing 1 spray at site 2 all the asulam and C + MM treatments were better than those of MM alone.

Experiment B: Effects on the number of bracken fronds

In the first year after treatment (Table 7) all except timing 1 treatments at site 7 and the low rate of C + MM at timing 3 at site 9 gave significant reductions in frond numbers.

In the second year after treatment (Table 8) all sprays at sites 5, 6 and 8 gave effective reductions. Only asulam at timing 2 and C + MM at timings 2 and 3 at site 7 gave good control. At site 9 only asulam gave effective control.

TABLE 1

Experiment A: Details of sites, management and assessments

Site number	1	2	3	4
Location	Marske N Yorks	Hurst Moor N Yorks	Fryup Dale N Yorks	Powys Wales
Herbage beneath bracken	Grass	Deep litter	Grass/Deep litter	Grass
Dates of spraying				
Early frond emergence	28/6/84	28/6/84	4/7/84	3/6/85
Height of Bracken	15-25 cms	15-25 cms	30-45 cms	50 cms
Full frond emergence	9/8/84	9/8/84	26/7/84	17/7/84
Assessment Dates				
Frond counts: Year 1	8/8/85	8/8/85	12/8/85	24/6/85
Year 2	26/6/86	30/6/86	23/7/86	16/7/86
Year 3	16/7/87	21/7/87	23/7/87	10/7/87

TABLE 2

EXPERIMENT B: Details of sites, management and assessments

Site number	5	6	7	8	9
Location	Marske N Yorks	Skipton N Yorks	Manaton Devon	Glaisdale N Yorks	Eskdale Cumbria
Herbage beneath bracken	Grass	Deep litter	Grass	Grass	Grass
Dates of spraying					
Early frond emergence	24/7/85	2/7/85	4/6/85	24/7/85	-
Height of Bracken	30-40 cms	30-45 cms	45 cms	50 cms	
Full frond emergence	29/8/85	30/8/85	18/7/85	12/8/85	29/7/85
Bracken senescing	20/9/85	23/9/85	24/9/85	26/9/85	27/9/85
Assessment Dates					
Frond counts: Year 1	26/6/86	24/9/86	12/9/86	24/9/86	4/7/86
Year 2	16/7/87	-	17/7/87	23/7/87	16/7/87

TABLE 3

Experiment A: Treatments and application timings

Treatment				Rate (ga.i.ha-1)	Timing
1	Metsulfuron-methyl		(MM1)	2.5	1
2	Metsulfuron-methyl		(MM2)	5.0	1
3	Metsulfuron-methyl		(MM3)	10.0	1
4	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM1)	7.5 + 2.5	1
5	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM2)	15.0 + 5.0	1
6	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM3)	30.0 +10.0	1
7	Metsulfuron-methyl		(MM1)	2.5	2
8	Metsulfuron-methyl		(MM2)	5.0	2
9	Metsulfuron-methyl		(MM3)	10.0	2
10	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM1)	7.5 + 2.5	2
11	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM2)	15.0 + 5.0	2
12	Chlorsulfuron	+ Metsulfuron-methyl	(C + MM3)	30.0 +10.0	2
13	Asulam		(A)	4.4 kga.i ha-1	2
14	Untreated				

Timing 1: Early frond emergence
Timing 2: Full frond emergence

TABLE 4

Experiment B: Treatments and application timings

Treatment and rate (g a.i.ha-1)						Timing
1 Chlorsulfuron	(7.5)	+	Metsulfuron-methyl	(2.5)	(C + MM1)	1
2 Chlorsulfuron	(15.0)	+	Metsulfuron-methyl	(5.0)	(C + MM2)	1
3 Chlorsulfuron	(22.5)	+	Metsulfuron-methyl	(7.5)	(C + MM3)	1
4 Chlorsulfuron	(30.0)	+	Metsulfuron-methyl	(10.0)	(C + MM4)	1
5 Asulam (4.4 kg ha^{-1})					(A)	1
6 Chlorsulfuron	(7.5)	+	Metsulfuron-methyl	(2.5)	(C + MM1)	2
7 Chlorsulfuron	(15.0)	+	Metsulfuron-methyl	(5.0)	(C + MM2)	2
8 Chlorsulfuron	(22.5)	+	Metsulfuron-methyl	(7.5)	(C + MM3)	2
9 Chlorsulfuron	(30.0)	+	Metsulfuron-methyl	(10.0)	(C + MM4)	2
10 Asulam (4.4 kg ha^{-1})					(A)	2
11 Chlorsulfuron	(7.5)	+	Metsulfuron-methyl	(2.5)	(C + MM1)	3
12 Chlorsulfuron	(15.0)	+	Metsulfuron-methyl	(5.0)	(C + MM2)	3
13 Chlorsulfuron	(22.0)	+	Metsulfuron-methyl	(7.5)	(C + MM3)	3
14 Chlorsulfuron	(30.0)	+	Metsulfuron-methyl	(10.0)	(C + MM4)	3
15 Untreated						

Timing 1: Early frond emergence
Timing 2: Full frond emergence
Timing 3: Bracken fronds senescing

TABLE 5

Experiment A: The effect of sulphonyl urea herbicides on the number of bracken fronds m² two years after treatment

Treatment	Timing	Site 3	Ctrl %	Site 4	Ctrl %	Site 1	Ctrl %	Site 2	Ctrl %
1 (MM1)	1	26	0	21	22	24	29	37	20
2 (MM2)	1	23	4	25	7	24	29	22	52
3 (MM3)	1	23	4	21	22	21	38	24	48
4 (C + MM1)	1	5	79	25	7	15	56	27	41
5 (C + MM2)	1	3	88	25	7	17	50	20	57
6 (C + MM3)	1	1	96	31	0	6	82	16	65
7 (MM1)	2	25	4	24	14	36	0	25	46
8 (MM2)	2	19	21	20	29	13	62	34	26
9 (MM3)	2	5	79	15	46	19	44	24	48
10 (C + MM1)	2	2	92	13	54	7	79	28	39
11 (C + MM2)	2	1	96	5	82	3	91	25	46
12 (C + MM3)	2	1	96	1	96	2	94	19	59
13 (A)	2	4	83	1	96	1	97	9	80
14 Untreated		24	0	28	0	34	0	46	0
SED +/-		4.2		6.2	7.7	5.1		10.5	

TABLE 6

Experiment A: The effect of sulphonyl-urea herbicides on the number of bracken fronds m² three years after treatment

Treatment	Timing	Site 3	Ctrl %	Site 4	Ctrl %	Site 1	Ctrl %	Site 2	Ctrl %
1 (MM1)	1	23	18			33	0	41	0
2 (MM2)	1	17	39			19	30	26	33
3 (MM3)	1	19	32			22	19	35	10
4 (C + MM1)	1	9	68			20	26	40	0
5 (C + MM2)	1	9	68			18	33	28	28
6 (C + MM3)	1	12	57			10	63	30	23
7 (MM1)	2	29	0	28	0	26	4	30	23
8 (MM2)	2	35	0	26	4	15	44	43	0
9 (MM3)	2	29	0	21	22	16	41	35	10
10 (C + MM1)	2	5	82	24	11	8	70	37	5
11 (C + MM2)	2	11	61	12	56	4	85	33	15
12 (C + MM3)	2	11	61	1	96	9	67	21	46
13 (A)	2	9	68	3	89	2	93	21	46
14 Untreated		28	0	27	0	27	0	39	0
SED +/-		7.4		6.5		3.5		7.3	

TABLE 7

Experiment B: The effect of sulphonyl-urea herbicides on the number of bracken fronds m² one year after treatment

Treatment	Timing	Site 5	Ctrl %	Site 6	Ctrl %	Site 7	Ctrl %	Site 8	Ctrl %	Site 9	Ctrl %
1 (C + MM1)	1	1	95	1	94	25	0	5	81	-	
2 (C + MM2)	1	2	91	0	100	22	8	3	88	-	
3 (C + MM3)	1	-		-		-		2	92	-	
4 (C + MM4)	1	1	95	0	100	34	0	1	96	-	
5 (A)	1	-		-		-		2	92	-	
6 (C + MM1)	2	2	91	6	63	1	96	1	96	15	55
7 (C + MM2)	2	0	100	0	100	1	96	2	92	4	88
8 (C + MM3)	2	-		-		-		2	92	4	88
9 (C + MM4)	2	1	95	0	100	1	96	1	96	-	
10 (A)	2	2	91	1	94	3	88	1	96	0	100
11 (C + MM1)	3	3	86	0	100	4	83	2	92	27	18
12 (C + MM2)	3	1	95	1	94	3	88	5	81	20	39
13 (C + MM3)	3	-		-		-		2	92	-	
14 (C + MM4)	3	1	95	0	100	4	83	3	88	22	33
15 Untreated		22	0	16	0	24	0	26	0	33	0
SED +/-		2.9		3.5		2.7		2.4		4.6	

- = Treatment not applied

TABLE 8

The effect of sulphonyl-urea herbicides on the number of bracken fronds m² two years after treatment

Treatment	Timing	Site 5	Ctrl %	Site 6	Ctrl %	Site 7	Ctrl %	Site 8	Ctrl %	Site 9	Ctrl %
1 (C + MM1)	1	7	63	1	90	27	0	20	39	-	
2 (C + MM2)	1	5	74	0	100	22	18	14	58	-	
3 (C + MM3)	1	-		-		-		5	85	-	
4 (C + MM4)	1	2	89	0	100	52	0	2	94	-	
5 (A)	1	-		-		-		6	92	-	
6 (C + MM1)	2	11	42	2	80	9	67	13	61	33	0
7 (C + MM2)	2	8	58	0	100	5	81	6	82	24	27
8 (C + MM3)	2	-		-		-		7	79	24	27
9 (C + MM4)	2	5	74	1	90	6	78	4	88	-	
10 (A)	2	2	89	0	100	4	85	1	97	0	100
11 (C + MM1)	3	16	16	2	80	11	59	20	39	31	6
12 (C + MM2)	3	10	47	0	100	8	70	13	61	23	30
13 (C + MM3)	3	-		-		-		5	85	-	
14 (C + MM4)	3	6	68	0	100	9	67	10	70	31	6
15 Untreated		19	0	10	0	27	0	33	0	33	0
SED +/-		4.0		2.0		4.9		4.2		5.5	

- = Treatment not applied

DISCUSSION

The effect of C + MM compared favourably with the level of control achieved with the standard treatment asulam. MM was not as effective as when mixed with C. It appears that C is the effective agent for bracken control in the mixture of the two sulphonyl-ureas. C + MM applied at full frond emergence gave the best results. Results with C + MM applied at early frond emergence and bracken senescing were quite similar overall, however results at the early timing were more variable. Comparing all the treatments in both experiments the best result which was comparable with the asulam control was obtained with the high rate of C + MM applied at full frond emergence.

Despite the variable results from C + MM applied at early frond emergence in practice these may be acceptable since it is safer and easier to apply ground applications at this time.

The sulphonyl-urea compounds chlorsulfuron and metsulfuron-methyl particularly in mixture are effective in controlling bracken which is an ever increasing problem particularly in some hill areas of the UK. Bracken is also a problem weed Internationally (Taylor 1985). In the UK the main reason for the apparent reduction in the area of bracken being sprayed is the high cost of chemical control.

The sulphonyl-ureas are cost effective and offer hope to the many hill farmers whose livestock productivity is restricted by bracken.

With conservation of the Uplands more important today than ever a cautious approach to the development of herbicides for use in these areas is important. It is essential however to continue to thoroughly evaluate potential herbicides over a wide range of sites at varied rates and timings.

ACKNOWLEDGEMENTS

The authors thank the farmers and landowners for the provision of trial sites; Du Pont (UK) Ltd and May and Baker for chemicals; colleagues at the Weed Research Division at Long Ashton Research Station and within the Agricultural Development and Advisory Service for their assistance.

REFERENCES

Birnie, R V (1985) Mapping bracken (Pteridium aquilinum) infestation in Scotland: an assessment of remote sensing-based mapping techniques, In Robertson R A (ed) Remote sensing in peat and terrain resource surveys, Proc Symp IPS Commission I, Aberdeen, 87-101.

Brown, R W (1985) Bracken in the North York Moors: its ecological and amenity implications, Proceedings Bracken 85 International Conference on the Bracken Fern, University of Leeds, 77-86

Bunce, R G H; Barr, C J; Whittaker, H A (1980) An integrated system of land classification. NERC, ITE, Annual Report, 28-34

Davies, G E; Newbold, D; Baillie, G J (1979) The effect of controlling bracken on pasture production. Grass and Forage Science 34, 163-16.

Hendre, G F (1958) The size of Scotland's bracken problem. Scot Agric Econ 9, 21-28.

Mackay, J T (1984) Paper presented at May and Baker Conference (1984)

Martin, D J (1976) Control of Bracken. Botanical Journal of the Linnaean Society 73, 241-246.

Oswald, A K; Richardson, W G; Flint, C E (1985) The effects of sulphonyl urea herbicides on Pteridium Aquilinum (Bracken) in hill pasture. Proceedings 1985 British Crop Protection Conference - Weeds, 779-785.

Oswald, A K; Richardson, W G; West, T M (1985) The potential control of bracken by sulphonyl-urea herbicides. Proceedings Bracken 85 International Conference on the Bracken Fern, University of Leeds, 431-440.

Soper, D (1970) The tolerance of pasture grasses to asulam. Proceedings 10th British Weed Control Conference, 465-475.

Taylor, J A (1978) The British Upland Environment and its management. Geog 63 (4), 338-353.

Taylor, J A (1985) The Bracken Problem: A Local Hazard and Global Issue. Proceedings Bracken 85 International Conference on the Bracken Fern. University of Leeds, 21-42.

Veeraseekaran, P; Kirkwood, R C; Fletcher, W W (1976) The mode of action of asulam (methyl (4-animo-benzenesulphonyl) carbamate) in bracken. Botanical Journal of the Linnaean Society 73, 247-268.

Williams, G H; Fraser, D (1978) The effects of asulam, frond cutting and ground mineral phosphate on the yield of swards dominated by bracken (Pteridium aquilinum (L) Kuhn). Grass and Forage Science 34, 95-100.

A SULFONYL-UREA MIXTURE FOR PTERIDIUM CONTROL

G. H. WILLIAMS

West of Scotland Agricultural College, Ayr

D. H. K. DAVIES

East of Scotland College of Agriculture, Edinburgh

ABSTRACT

A comparison of bracken (Pteridium aquilinum) frond control with a chlorsulfuron/metsulfuron-methyl mixture and with asulam showed that asulam at 4.4 kg a.i./ha gave better long-term control than the mixture at 40 g a.i./ha when spraying was carried out between mid-July and mid-August. The mixture was more effective than asulam when applied to fronds which were beginning to senesce although there could be appreciable regeneration in the second year after treatment. The use of the chlorsulfuron/metsulfuron-methyl mixture could extend the bracken spraying season if the farmer was prepared to adopt a level of post-treatment management which severely inhibited frond regrowth. The mixture is likely to be considerably cheaper than asulam but the addition of non-ionic wetter was essential for good results. Neither asulam nor chlorsulfuron/metsulfuron-methyl showed any significant long-term damage to the species present in the underlying swards in these trials.

INTRODUCTION

Bracken (Pteridium aquilinum) is an important weed in hill pastures in many parts of the United Kingdom. Since the early 1970's, the main method of control has been by spraying with asulam. This gives excellent results provided that timing and application techniques are correct (Soper, 1986) but although the area of agricultural land infested by bracken is increasing (Taylor, 1985), the area treated each year in order to control the weed has probably remained almost static (McCreath, 1982). There are three main reasons for this:

1. The initial cost, especially in a period of uncertain profitability for hill farming.

2. Limited opportunities for spraying. In most cases, asulam gives good control only when applied between mid-July and mid-August. Scottish weather at this time is notoriously uncertain, with frequent rainfall and often high winds. While this has not stopped contractors from carrying out the limited amount of bracken control with herbicides currently being undertaken, it could cause problems if there was an increase in the area to be treated each year.

3. The problems of changed management techniques in order to maintain and justify the improvements resulting from bracken clearance.

A chlorsulfuron/metsulfuron-methyl mixture has shown promise for bracken control, probably at a lower cost than asulam (Oswald, Richardson & West, 1986) and trials in Scotland (Davies & Williams, 1987) suggested that useful control could be obtained from treatments applied outwith the mid-July to mid-August period. Although applications at the crook stage in June were ineffective, spraying as late as the end of September gave good frond control in the following year. This paper reports the results of further assessments made in the summer of 1987, three years after the original trial commenced in 1984 with chlorsulfuron/metsulfuron-methyl applied at the conventional time, and two years after applications as late as the end of September were made.

METHODS

Trial Sites

The trial sites used were at Monksfoot, Glespin, Lanarkshire and House o' Muir, Bush, Penicuik, Midlothian. Both sites have a short growing season. At Monksfoot, frond emergence does not occur until mid- to late May and wind funnelling up the valley may damage fronds after mid-August, while at House o' Muir, drought conditions on the dry mineral soil slopes can cause severe water stress.

Treatments

Details of treatments are given in Table 1 and the stages of frond growth at the different treatment dates in Table 2. At Monksfoot, all treatments were applied by hand-held sprayer at 400 l/ha as a coarse spray. The plot size was 5 x 2.5 m and there were two replicate blocks in 1984 and three in 1985. At House o' Muir, the treatments were applied by Van der Weij pressurised knapsack sprayer at 200 l/ha with Teejet 800 nozzles at 2 bars pressure. The plot size was 6 x 4 m and there were three replicate blocks in both years.

Assessments

Counts were made of frond numbers after full frond emergence. Results from Monksfoot are the mean of 2 x 1 m^2 quadrat frond counts/plot. House o' Muir results are the mean of 6 x 0.25 m^2 quadrat frond counts/plot and include an estimate of the vigour of fronds on a scale of 0-10. Assessments were made of sward composition (% ground cover) at Monksfoot in mid-June in 1985 and 1987, before the first pinnae were expanded on the bracken fronds. Assessments of grass vigour, on a scale of 0-10, have been made at House o' Muir while counting frond numbers.

RESULTS

1984 Treatments

At both sites, asulam applied before frond senescence gave the expected level of control. Asulam-treated plots at House o' Muir showed 3.4 fronds/m^2 in 1985, 3.1 in 1986 and 2.4 in 1987, compared with frond numbers in untreated plots of 23.8/m^2, 28.4/m^2 and 18.4/m^2 respectively but the results obtained with the chlorsulfuron/metsulfuron-methyl mixture were

TABLE 1

Treatments

Site	Application date	Treatment	Rate g a.i./ha	Wetter l/ha
Monksfoot	24.7.84	Asulam	4400	0.4
	20.8.84	Chlorsulfuron + metsulfuron-methyl	10	1.0
			20	1.0
			40	1.0
		Asulam	4400	0.4
	22.8.85	Chlorsulfuron + metsulfuron-methyl	30	0.5
			30	1.0
			40	1.0
	6.9.85	Chlorsulfuron + metsulfuron-methyl	30	0.5
			30	1.0
			40	1.0
	25.9.85	Chlorsulfuron + metsulfuron-methyl	30	0.5
			30	1.0
			40	1.0
		Asulam	4400	0.4
House o' Muir	8.8.84	Chlorsulfuron + metsulfuron-methyl	10	0
			20	0
			40	0
		Asulam	4400	0.4
	30.7.85	Chlorsulfuron + metsulfuron-methyl	20	0
			20	0.4
			40	0
			40	0.4
	17.8.85	Chlorsulfuron + metsulfuron-methyl	20	0
			20	0
			30	0.4
			40	0
			40	0.4
		Asulam	4400	0.4
	6.9.85	Chlorsulfuron + metsulfuron-methyl	20	0
			20	0.4
			40	0
			40	0.4

TABLE 2

Stages of frond growth

Site	Date	Frond growth stage
Monksfoot	24.7.84	Pinnae fully expanded
	20.8.84	Slight frond senescence
	22.8.85	Fronds mature; no senescence
	6.9.85	Slight frond senescence
	25.9.85	Fronds 50% senesced
House o' Muir	8.8.84	Pinnae fully expanded
	30.7.85	Pinnae 90% expanded
	17.8.85	Pinnae fully expanded
	6.9.85	Fronds 20% senesced

very disappointing. At Monksfoot (Table 3), the mixture gave better control than asulam when applied on 20 August, when there was slight frond senescence.

TABLE 3

Bracken control at Monksfoot following 1984 treatments

Application date	Treatment	Rate g ai/ha	Wetter l/ha	Fronds/m^2 1985 (SE)	1986 (SE)	1987 (SE)
24.7.84	Asulam	4400	0.4	0.1 (0.3)	1.2 (0.5)	3.6 (1.4)
20.8.84	Asulam	4400	0.4	3.5 (1.0)	9.3 (1.5)	13.0 (3.2)
	Mixture	10	1.0	1.0 (0.8)	1.3 (0.9)	5.0 (2.1)
		20	1.0	0.3 (0.5)	0.8 (0.5)	4.5 (2.2)
		40	1.0	0.1 (0.5)	0.8 (0.5)	2.8 (0.9)
	Untreated			18.7 (3.9)	20.3 (7.5)	19.2 (7.8)

Sward composition showed no significant differences between herbicide treatments, except in so far that it reflected the level of frond control achieved. Assessments from individual plots were very variable, but the results (Table 4) suggested no markedly damaging effects on any of the species present and the main effect of frond clearance was a reduction in the amount of litter-covered ground which allowed Festuca rubra, Anthoxanthum odoratum and, to a certain extent, mosses to increase.

TABLE 4

Sward composition at Monksfoot following 1984 treatments

	% ground cover							
Treatments	1		2		3		4	
Year	1985	1987	1985	1987	1985	1987	1985	1987
Festuca rubra	27.1	28.2	18.1	36.9	22.6	35.0	18.8	33.4
Anthoxanthum odoratum	5.8	4.5	12.4	22.2	7.5	24.0	12.3	26.4
Deschampsia flexuosa	2.5	2.1	6.2	4.7	2.7	2.5	2.8	2.6
Agrostis capillaris	3.3	1.9	1.7	6.1	0.5	6.3	4.4	6.1
Potentilla erecta	3.0	3.1	2.6	3.1	3.5	2.8	2.0	2.3
Galium saxatile	5.8	7.8	3.5	6.4	4.2	6.6	5.8	8.4
Mosses	10.0	12.4	11.3	15.2	15.7	18.4	9.1	15.3
Other spp	0.4	0.4	0.6	0.8	3.4	1.3	1.7	1.8
Bare (Litter)	42.1	39.6	43.6	4.6	39.9	3.1	43.1	3.7

Treatment 1: Untreated control
Treatment 2: Asulam applied 24.7.84
Treatment 3: Asulam applied 20.8.84
Treatment 4: Mean of sulfonyl urea mixture applications on 20.8.84

1985 Treatments

House o' Muir

The results from the House o' Muir trial (Table 5) showed very clearly that the chlorsulfuron/metsulfuron-methyl mixture gave poor control if applied without added wetter, and that better results were obtained with treatments in the period from the end of July to mid-August. There was also no particular significant effect on sward vigour in 1987 (Table 6).

At House o' Muir, the number of fronds/m^2 in control plots in 1987 was markedly lower than in 1986, while the farmer at Monksfoot made the observation that he did not think that the bracken was as dense as usual, although this did not show up in counts of frond numbers on control plots in the trial area (Table 7). The results at Monksfoot showed that chlorsulfuron/metsulfuron-methyl was continuing to give a significant reduction in frond numbers but there was considerable regeneration compared with 1986.

DISCUSSION

Our conclusions from the results of assessments made in 1986 (Davies & Williams, 1987) were that the chlorsulfuron/metsulfuron-methyl mixture showed a level of activity in controlling bracken fronds at least comparable with that of asulam. Following a further year of observations of

TABLE 5

Bracken control at House o' Muir following 1985 treatments

Application date	Treatment	Rate g ai/ha	Wetter l/ha	Frond number/m²		Frond vigour	
				1986	1987	1986	1987
30.7.85	Chlorsulfuron + metsulfuron-methyl	20	0	10.4	18.0	3.2	8.3
		20	0.4	1.1	3.6	0.5	3.3
		40	0	4.0	10.4	2.7	6.3
		40	0.4	1.8	5.3	1.3	5.7
17.8.85	Chlorsulfuron + metsulfuron-methyl	20	0	13.6	17.8	4.3	8.3
		20	0.4	2.9	7.1	2.0	4.3
		30	0.4	1.6	5.1	1.5	4.7
		40	0	4.7	11.8	2.8	5.7
		40	0.4	1.8	6.2	1.8	5.0
	Asulam	4400	0.4	1.6	2.9	0.7	2.7
6.9.85	Chlorsulfuron + metsulfuron-methyl	20	0	12.0	21.1	5.0	7.3
		20	0.4	19.8	16.4	6.8	8.7
		40	0	6.4	12.4	2.7	5.7
		40	0.4	4.4	7.8	2.2	5.0
	Untreated			26.0	17.1	6.5	7.7
	SED (±)			4.2	3.2	1.2	1.0

the results of our trials, it is possible to qualify this statement.

It should be emphasised that both trial sites have a short growing season and that the optimum time for asulam application for bracken control could well be less than the normal period of mid-July to mid-August. There is also, in small-plot trials, a certain amount of reinvasion of bracken from surrounding areas which can upset longer term assessments based on frond counts. Nevertheless, long-term control of frond growth with chlorsulfuron/metsulfuron-methyl does not appear to be as good as with asulam when spraying is carried out between mid-July and mid-August. It is possible that this depends on the amount of wetter which is added. Overall, the mixture's effectiveness seems to be much more dependent on wetter concentration than is that of asulam. In the absence of wetter, chlorsulfuron/metsulfuron-methyl gave poor control even in applications made at the end of July when conditions for uptake and translocation should have been ideal, and this almost certainly explains the lack of success in the 1984 trials at House o' Muir.

On the other hand, the mixture with added wetter gave better control than asulam when applied to fronds which were beginning to senesce, although bracken regeneration in the second year after spraying could be appreciable. It has been shown (Williams, 1980), however, that the rate of regeneration of fronds following asulam spraying is very dependent on after-treatment and if a farmer is prepared to increase stocking levels,

TABLE 6

Sward vigour at House o' Muir in 1987

Application date	Treatment	Rate g ai/ha	Wetter l/ha	Sward vigour
30.7.85	Chlorsulfuron + metsulfuron-methyl	20	0	7.3
		20	0.4	8.0
		40	0	7.0
		40	0.4	8.7
17.8.85	Chlorsulfuron + metsulfuron-methyl	20	0	9.0
		20	0.4	7.0
		30	0.4	7.7
		40	0	6.7
		40	0.4	7.0
	Asulam	4400	0.4	7.3
6.9.85	Chlorsulfuron + metsulfuron-methyl	20	0	6.7
		20	0.4	8.0
		40	0	7.0
		40	0.4	7.3
	Untreated			7.3
	SED (±)			1.1

TABLE 7

Bracken control at Monksfoot following 1985 treatments

Application date	Treatment	Rate g ai/ha	Wetter l/ha	Fronds/m² 1986 (SE)	Fronds/m² 1987 (SE)
22.8.85	Chlorsulfuron + metsulfuron-methyl	30	0.5	0.2 (0.4)	3.0 (1.8)
		30	1.0	0.3 (0.5)	3.5 (1.7)
		40	1.0	0.2 (0.4)	4.8 (1.9)
6.9.85		30	0.5	0.7 (0.8)	8.3 (2.2)
		30	1.0	0.3 (0.5)	4.8 (1.6)
		40	1.0	0.3 (0.5)	5.4 (1.7)
25.9.85		30	0.5	4.8 (2.0)	10.2 (2.4)
		30	1.0	4.0 (1.4)	7.3 (2.0)
		40	1.0	3.2 (1.0)	6.7 (1.5)
	Asulam	4400	0.4	12.0 (2.6)	11.5 (2.1)
	Untreated			21.3 (5.6)	18.5 (5.9)

especially of cattle, short-term frond control which removes the risk of poisoning may be adequate. The chlorsulfuron/metsulfuron-methyl mixture, which is likely to be considerably cheaper than asulam, could have a significant part to play in bracken control programmes when hill farmers regain some confidence in their future.

ACKNOWLEDGEMENTS

We thank P. Newbould, Macaulay Land Use Research Institute, T. Steele and M.C.Richards for assistance with these trials.

REFERENCES

Davies, D.H.K.; Williams, G.H. (1987) Activity of sulfonyl-urea herbicides on Pteridium aquilinum in the South of Scotland. Proceedings Crop Protection in Northern Britain, 1987, 355-360.

McCreath, J.B. (1982) Some reflections and projections on bracken control. Proceedings of the Royal Society of Edinburgh 81B: 135-143.

Oswald, A.K.; Richardson, W.G.; West, T.M. (1986) The potential control of bracken by sulphonyl-urea herbicides. In: Bracken: ecology, land use and control technology R.T.Smith and J.A.Taylor (Eds), Parthenon, pp 431-439.

Soper, D. (1986) Lessons from fifteen years of bracken control with asulam. In: Bracken: ecology, land use and control technology R.T.Smith and J.A.Taylor (Eds), Parthenon, pp 351-357.

Taylor, J.A. (1985) Bracken encroachment rates in Britain. Soil Use and Management 1, 53-56.

Williams, G.H. (1980) Follow-up treatments for control of Pteridium aquilinum. Proceedings 1980 British Crop Protection Conference-Weeds, 423-428.

CREATION OF WOODLAND BY DIRECT SEEDING WITH HERBICIDE MANAGEMENT

P.D. PUTWAIN

Department of Botany, University of Liverpool, Liverpool, U.K.

B.E. EVANS, S. KERRY

County Planning Department, Gwent County Council, Cwmbran, Gwent, U.K.

ABSTRACT

As an alternative to the use of transplanted nursery stock, woodland can be established by the direct seeding of trees and shrubs at the location where they are to grow. An experiment was established in September 1983 on a road embankment to test the effectiveness of the direct seeding method. The experimental treatments included addition of three levels of inorganic fertiliser and application of a residual herbicide (propyzamide) to control the growth of competitive grasses. There was substantial germination and establishment of tree seedlings in spring and summer 1985. The most successful species were Ash (Fraxinus excelsior), Hawthorn (Crataegus monogyna) and Maple (Acer campestre). Maximum possible establishment and growth of tree seedlings was achieved by controlling the growth of competitive grasses with propyzamide. Addition of inorganic fertiliser at a high rate also enhanced growth and herbicide plus fertiliser interacted to give the highest seedling establishment combined with greatest subsequent growth. Establishment of woodland by direct seeding will cost 30%-50% less than traditional methods of transplanting trees.

INTRODUCTION

Over a period of many years conservation organisations (e.g. Nature Conservancy Council, 1977) and the Countryside Commission have stressed the deleterious impact upon landscape and wildlife caused by removal from agricultural land of hedgerows and small woodlands, particularly those composed of native broadleaved species.

The losses have been mitigated to some extent by the actions of local authorities who have made considerable contributions to landscape amenity and nature conservation through the establishment and management of woodland in country parks, along roadsides and through the reclamation of derelict land to amenity use. The current changing emphasis in agricultural land management will probably result in new planting of woodland and restoration of hedgerows, at least in less intensively farmed areas of Britain.

New development work will be required to introduce low-cost but reliable methods for the establishment of indigenous trees and shrubs. The traditional, but financially costly, method for establishing woodland involves either notch planting of forest transplants or whips with added fertilizer or transplanting larger trees in pits with addition of a proprietary tree compost. Poor quality nursery stock, late planting, poor handling and planting technique and sometimes spring droughts cause establishment failure. Thus varying numbers of costly replacements are often required at the end of the first growing season and again in subsequent years.

An alternative, potentially low-cost approach to the creation of woodland is to directly seed tree and shrub species at the location where the woodland will be established. Direct seeding of trees has been widely used in the U.S.A., Canada and Scandinavia for replanting coniferous forests (Davidson, 1980) and has been used in West Germany to establish woodland alongside highways (Luke et al., 1982). In the United Kingdom direct seeding of trees has been utilised to establish woodland landscape in Kent (La Dell, 1983) and is gradually becoming a more commonly used technique on land reclamation sites, roadsides and derelict urban sites (Buckley, 1984).

A potentially serious drawback to the use of direct seeding as a means of creating woodland is failure of seeding establishment or reduced growth of seedling trees due to competition from associated herbaceous plants and grasses which will inevitably colonise areas sown with trees. In orchards competition for soil moisture has been recognised as the main adverse effect of grasses and herbaceous plants (White & Holloway, 1967; Atkinson and Petts, 1978).

In order to investigate the efficacy of direct seeding of trees, an experiment was established on a roadside in Gwent, South Wales, to examine the establishment and early growth of tree seedlings. In order to determine the significance of competition by species of grasses, a herbicide treatment designed to control growth of grasses was factorially combined with a fertilizer treatment designed to enhance the growth of both tree species and associated grass and herbaceous species. An additional objective was to examine the cost-effectiveness of direct seeding in comparison with traditional methods of tree planting.

MATERIALS AND METHODS

Site characteristics and seed-bed preparation

The experimental site was located alongside the Crumlin to Aberbeeg new A467 road (in Gwent). The area (0.43 ha) of roadside embankment consisted of a substrate of colliery shale wastes and boulder clay subsoil including relatively large stones. The existing herbaceous sward was sprayed with glyphosate in August 1983 and was sprayed again with paraquat in September. All existing vegetation was killed.

The area was subsequently cultivated to a depth of 22.5 cm with several passes of a disc harrow. An attempt to produce a tilth was made using chain harrows. Stones, metal and timber larger than 50mm were collected mechanically and removed from the site. Lime (2510 kg ha^{-1}) and compound fertilizer (376.5 kg ha^{-1}; 5, 24, 24) were harrowed in and a grass/herbage legume seeds mixture, winter barley, tree and shrub seed were broadcast by hand on 26 September 1983. The area was not subsequently harrowed or rolled due to poor weather conditions, although this was an intended procedure.

Seed mixtures

The grass/herbage legume seeds mixture consisted of the following species and seed rates per hectare; *Agrostis castellana* cv. Highland (4.65 kg ha^{-1}), *Festuca rubra* cv. Dawson (4.65 kg ha^{-1}), *Trifolium repens* cv. Kent Wild White (0.70 kg ha^{-1}), *Lotus corniculatus* (0.58 kg ha^{-1}), *Melilotus officinalis* (0.58 kg ha^{-1}) and *Medicago sativa* (0.38 kg ha^{-1}). Winter barley was sown at a rate of 56.0 kg ha^{-1}. The weight and approximate number of the tree and shrub species which were sown in September 1983 are given in Table 1. The emergence of *Quercus robur*, *Fagus sylvatica*, *Corylus avellana* and *Betula pendula* was very poor in summer 1984. Therefore 50 seeds per plot of *Q. robur* and *Q. petraea*, *F. sylvatica* and *C. avellana* were sown (individually dibbed in by hand) in November 1984 whilst 50 grammes per plot of *B. pendula* was sown in March 1985. Half of the experimental area was sown with tree lupin (*Lupinus arboreus*) and perennial lupin (*L. perennis*). However, this report is not concerned with the influence of shrubby legumes on establishment of tree seedlings and this part of the experiment is not considered further.

Fertilizer and herbicide treatments

The experimental design incorporated 3 levels of fertilizer; control (no fertilizer added), low fertilizer (50 kg ha^{-1} Enmag, 6 : 20 : 10 and 100 kg ha^{-1} ICI No. 5, 17 : 17 : 17) and high fertilizer (150 kg ha^{-1} Enmag and 300 kg ha^{-1} ICI No. 5). Fertilizer was applied in July 1984 and again in July 1986.

There were two herbicide treatments, plus and minus propyzamide. The differential herbicide treatment did not commence until January 1986. By autumn 1984 the growth of grasses was substantial on all experimental treatments and tree and shrub seedling establishment was likely to be severely retarded. Therefore the entire experimental area was treated with propyzamide granules (15.0 kg ha^{-1}) in December 1984. Subsequently propyzamide granules were applied at the same rate to the plus herbicide plots on 28 January 1986.

Experimental design, plot dimensions and layout

The herbicide treatment comprised eight main-plots (65.0m x 8.3m) which were subdivided into three (equal-sized) sub-plots. Four of the main-plots were randomly assigned the plus propyzamide treatment and the other four were minus herbicide. The fertilizer treatments (control, low, high fertilizer) were randomly assigned within the main-plots. Sub-plot dimensions were 21.6m x 8.3m

Monitoring of tree seedling emergence and survival

The emergence, early establishment and subsequent survival of tree seedlings was monitored during 1984, 1985 and 1986. In August 1984 the entire experimental area was thoroughly searched by dividing each sub-plot into strips 2m in width. The position of each individual seedling was mapped and its field location marked with a split cane. Subsequently in 1985 when a large number of seedlings emerged, a sampling procedure was adopted. Two x 4m^2 permanent sampling areas were located in each sub-plot. The position of each sample plot was located at random from a possible 40 positions within each plot. Within each sample plot the total number of seedlings of each tree species was recorded and in addition a minimum of 10 seedlings were marked using a wire ring with a numbered tag attached. The seedlings were censused in July 1985, October 1985, and July 1986 to determine the survival of individuals. In addition the height and diameter (using calipers measuring 2.0cm above ground) of seedlings was recorded in October 1985 and July 1986. Seedling height was statistically analysed by analysis of variance.

RESULTS

The effectiveness of barley as a ground stabilising plant

Winter barley germinated during October 1983 and became well-established before the winter. The barley population provided very effective soil stabilisation through the winter months and there was very little development of rills or gulleys on the experimental site. The barley population density was 48 plants per m^2 in May 1984 which was quite adequate for stabilising the ground surface for an extended period, autumn to spring.

The emergence, establishment and survival of trees and shrubs

In 1983 the spring and early summer were exceptionally dry and there were very few emerged seedlings in the July census. Drought was not the only reason for this since the seed of many of the species was dormant and would not necessarily be expected to germinate in the first growing season after sowing. There was an increase in rainfall in late summer and limited germination of Sarothamnus scoparius occurred at this time.

Since there were so few emerged tree seedings, long-term monitoring of these commenced in summer 1985. The most abundant species were Fraxinus excelsior, Crataegus monogyna and Acer campestre whilst Alnus glutinosa and Fagus sylvatica were completely absent.

Species seedling numbers apparently differed in response to the experimental treatments although the differences were not statistically significant for any of the species. The total number per unit area of F. excelsior seedlings was favoured by application of herbicide and high fertiliser input. The establishment of C. monogyna seedlings were clearly sensitive to competition from grasses since numbers were consistently greater in the plus herbicide treatment whilst seedling numbers were greatly reduced in the minus herbicide and high fertiliser treatment. There was a response in the number of Quercus spp. to input of fertiliser but the influence of grass competition was only apparent in the minus herbicide and high fertiliser treatment where seedling density was substantially less.

The proportion of marked tree seedlings surviving during 1985 and until July 1986 is given in Table 2. Generally seedling survival was high for all species during summer 1985. However there was differential species mortality during winter 1985/86 and in spring 1986 after which treatment effects became more pronounced.

The main features of the data are the relatively high survival of F. excelsior in all treatments except minus herbicide and zero fertiliser, whilst competition from grasses did not influence the survival of seedlings with addition of fertiliser. Seedling survival of C. monogyna and Quercus spp. was greater in the plus herbicide treatment and an interaction of high fertiliser with the presence of grasses (minus herbicide) caused considerable seedling mortality. There was a less clear pattern of response by A. campestre but survival was particularly poor in the zero fertiliser minus herbicide treatment. Survival of Rosa canina was negligible in the absence of added mineral nutrients but the significance of the herbicide treatment was less obvious. It is clear that suppression of the growth of grasses using an application of propyzamide in mid-winter enhanced the establishment and survival of most tree species.

The growth of trees

The height of tree seedlings was measured as a non-destructive index of their growth. Stem diameter was also measured but it is not reported in this paper. The mean height of the three most common species is given in Table 3. The shoot growth of all three species was satisfactory overall, particularly since relatively more resources enter into root growth at this early stage in plant development. The relatively cool, moist summers of 1985 and 1986 undoubtedly assisted the establishment and early growth of tree seedlings.

The high input of fertiliser resulted in a substantial increase (statistically significant $P = 0.001$) in height growth in all three species, A.campestre and C. monogyna showed the greater responses of shoot height to fertilizer input. The application of propyzamide produced a consistent response with a statistically significant ($P = 0.05$) increase in the shoot growth of all species. However, there was a differential response of the three species. In particular, high mineral nutrient input caused relatively good shoot growth of F.excelsior and A.campestre even in the presence of competing grasses (minus herbicide). Thus improved nutrition to some extent overcame the impact of competition from grasses. However, in all three tree species the greatest growth occurred on the plus herbicide treatment with high fertiliser input. There was poor growth of F.excelsior and A.campestre in the control treatment where grass competition was not alleviated by increased mineral nutrient input.

The cost of the creation of woodland by direct seeding

The creation of amenity woodland by direct seeding on road verges and embankments, on disturbed and derelict land and on agricultural fringe areas, will

TABLE 1

Tree and shrub seed sown alongside Crumlin/Aberbeeg New A467 Road

Common name	Latin name	Amount sown	Seed per m^2	Total seed experimental area (approximately)
Birch	Betula pendula	2 kg	808	3,400,000
Alder	Alnus glutinosa	2 kg	404	1,700,000
Hawthorn	Crataegus monogyna	10 kg	20	86,000
Rowan	Sorbus acuparia	3 kg	154	645,000
Ash	Fraxinus excelsior	12 kg	32.5	140,000
Beech	Fagus sylvatica*	2.8 kg	0.28	1,200
Oak	Quercus robur and Q. petraea*	8 kg	0.56	2,400
Dog Rose	Rosa canina	1 kg	65	275,000
Broom	Sarothamnus scoparius	1.5 kg	70	300,000
Maple	Acer campestre	3.0 kg	8.5	36,000
Holly	Ilex aquifolium	1.0 kg	3.5	15,000
Hazel	Corylus avellana*	10.0 kg	0.28	1,200

*Sown November 1984

TABLE 2

The proportion of marked tree seedlings surviving four months and thirteen months. Data from 8 replicate sampling areas.

Species		June 1985 until October 1985*			June 1985 until July 1986		
		Control	Low fert	High fert	Control	Low fert	High fert
Fraxinus excelsior	+H	0.77	0.82	0.87	0.64	0.62	0.69
	-H				0.47	0.63	0.71
Crataegus monogyna	+H	0.79	0.61	0.81	0.44	0.43	0.59
	-H				0.44	0.38	0.28
Acer campestre	+H	0.91	0.93	0.76	0.52	0.35	0.52
	-H				0.19	0.45	0.30
Quercus spp.	+H	no data available			no data	1.00	1.00
	-H					0.83	0.60
Rosa canina	+H	0.51	0.80	0.70	0.00	0.39	0.38
	-H				0.05	0.38	0.22

+H Plus propyzamide treatment
-H No herbicide applied

* Since the herbicide treatment had not commenced in June 1985, these data are mean values for the pooled +H and -H treatments.

TABLE 3

The mean height of tree seedling (cm), October 1985 and July 1986.

Species		October 1985* Control	Low fert	High fert	July 1986 Control	Low fert	High fert	LSD [o] P=0.05
Fraxinus excelsior	+H	5.00	4.60	6.65	10.78	9.70	17.50	2.57 (H)
	-H				7.63	9.38	13.30	3.14 (F)
Crataegus monogyna	+H	5.00	5.95	7.15	15.43	11.48	30.55	5.37 (H)
	-H				9.47	8.75	18.63	6.42 (F)
Acer campestre	+H	5.75	7.20	11.00	13.83	10.00	27.80	4.88 (H)
	-H				4.95	7.80	22.43	5.98 (F)

+H Plus propyzamide treatment
-H No herbicide applied

* Since the herbicide treatment had not commenced in June 1985, these data are mean values for the pooled +H and -H treatments.

[o] For each species, LSD (P = 0.05) Herbicide comparison (H), Fertiliser comparison (F)

TABLE 4

Comparative cost of establishment of amenity woodland by direct seeding or by transplants per hectare

Transplanting	£	Direct seeding	£
Initial cost of seedbed preparation and sowing legume/grass seeds mixture	800	Herbicide spray over the entire area	150
		Seeding; Cost of materials	
Site preparation; Spot weeding of tree sites	60	Tree seed, a mixture of species; herbaceous and shrubby legumes	1000
Planting costs;			
3,500 (transplants) to 6,500 (transplants) per hectare at £0.92 per transplant	3220-5980	Seed rate designed to give at least 10,000 established tree seedlings per hectare after 3 years	
Maintenance; 20% of planting costs to cover 3 years maintenance	644-1196	Cultivation of area, incorporating fertilizer and sowing tree seed	850
Cost to establish amenity amenity woodland on a bare site		Maintenance; herbicide and fertilizer to cover 3 years maintenance	600
Total cost	£3864-7176	Total cost	£2600
Cost to establish amenity amenity woodland on a site previously prepared with a grass/legume sward		Alternatively on steep slopes hydraulic application of seed, fertilizer and mulch	2250
Total cost	£4724-8036	Total cost	£4000

only become a widely used method if it is not only technically successful in a variety of environments, but is also substantially less expensive than the traditional method of transplanting young trees.

A comparison of the cost of direct seeding with transplanting in made in Table 4 in which contractors costings provided by Gwent County Council for two traditional roadside planting schemes are used as the basis of comparison with direct seeding. It is assumed that the cost of providing rabbit proof and/or stock poor fencing will be the same for transplants and direct seeding.

Ignoring fencing costs, direct seeding is 30%-50% less expensive than transplants on sites where mechanised seed bed preparation and sowing of seed is possible. This will be on sites which have shallow gradients (slopes less than 12^{o}). Somewhat steeper slopes can be worked using a tractor with tracks, combined with hand sowing. Costs will remain substantially less than for transplants.

CONCLUSIONS

The experimental establishment of trees and shrubs by direct seeding has been very successful during the seedling establishment stage of woodland development. The initial establishment of barley to assist soil surface stabilisation during the first winter, was very effective and can be recommended as a standard practice in the future. There are strong indications that grasses should not be included in the seed mixture of herbaceous plants. There was a harmful influence of competition from grasses on both the survival (except F.excelsior) and early growth of trees seedlings. This must be minimised, so that not sowing grasses is the logical conclusion.

In the early phase of woodland development at the Crumlin/Aberbeeg site, the most successful tree species were F.excelsior, C.monogyna and A.campestre. These are all species with medium sized seeds and a high proportion of dormant seeds in the population. Other species that show reasonable promise are Q.robur, Q.petraea and C.avellana. The most successful shrub was R.canina although S.scoparius was also reasonably abundant. Quercus spp. and C.avellana have a high rate of survival once emerged but predation by birds and small mammals probably reduced seed numbers before germination had commenced. Species with small seeds such as B.pendula and A.glutinosa failed almost completely. A combination of dry periods of weather during summer 1984 and competition from grasses and clovers was probably the main cause of failure.

The application of the herbicide propyzamide was very beneficial to seedling establishment, subsequent survival and early growth. The benefit was enhanced by a high input of mineral nutrients. No after-management (i.e. zero fertiliser input and no herbicide treatment) resulted in fewer trees which had poor growth. Certain species, particularly F.excelsior and A.campestre, once established, appeared to grow reasonably well in the presence of competition by grasses provided that there was high mineral nutrient input. Insufficient time has elapsed for a critical appraisal of the cost-benefit of the herbicide treatment, but at present the cost of the herbicide appears to be very worthwhile.

On gently sloping and level sites it appears that establishment of woodland by direct seeding will be considerably less expensive (up to 50% less) than traditional methods of transplanting whips or forest transplants. Further experiments in progress indicate that even on steeper slopes, sowing a cereal may be an effective approach to provision of a straw mulch at a very reasonable cost, when mechanised sowing is not possible.

ACKNOWLEDGEMENTS

We are most grateful to the Gwenty County Engineer and Surveyor who assisted with provision of a suitable experimental site and provision of funds for the initial work. We are also grateful to the Welsh Office through Mr R.A. Page (Environmental Protection Unit) who have provided finance for the continuing monitoring of the scheme.

REFERENCES

Atkinson, D.; Petts, S.C. (1978) Effect of the chemical management of orchard swards on the use of water and mineral nutrients. Proceedings 1978 British Crop Protection Conference - Weeds, 223-230.

Buckley, G.P. (1984) The uses of herbaceous companion species in the establishment of woody species from seed. Journal of Environmental Management, 18, 309-322.

Davidson, W.H. (1980) Direct seeding for forestation. In Trees for Reclamation. General Technical Report, NE-61. Broomall, Pennsylvania : North-East Forest Experimental Station.

LaDell, T. (1983) An introduction to tree and shrub seeding. Techniques No.44, Landscape Design, 8, 27-31.

Luke, A.G.R.; Harvey, H.J.; Humphries, R.N. (1982) The creation of woody landscapes on roadsides by seeding - a comparison of past approaches in West Germany and the United Kingdom. Reclamation and Revegetation Research, 1, 243-253.

Nature Conservancy Council (1977) Nature Conservation and Agriculture. NCC London.

White, G.C.; Holloway, R.I.C. (1967) The influence of simazine or a straw mulch on the establishment of apple trees in grassed down or cultivated soil. Journal of Horticultural Science, 42, 337-389.

THE EFFECT OF WEEDS ON TREE ESTABLISHMENT

C.J. POTTER, S. COLDERICK

Forestry Commission Research Station, Alice Holt Lodge, Farnham, Surrey England

ABSTRACT

An experiment investigating the effect of weeds on the growth and nutrient status of young trees is described. Following results from previous experiments, water and nitrogen relations were chosen for specific investigation. The effect of irrigation and/or nitrogen application on trees growing in bare earth and weedy plots was assessed. The results are reported in terms of height and diameter growth and foliar nutrient concentrations and the implications for the establishment of young trees are discussed.

INTRODUCTION

Young trees, wherever they are planted, usually have to struggle to survive. Two of their basic needs - water and nutrients - are often severely restricted due to site conditions and competition from weeds. Of these, the latter is both the most prevalent and the easiest to alleviate.

Over the past ten years many experiments on a wide range of sites and species have shown that the presence of weeds has a deleterious effect on tree survival and growth. (Insley and Buckley, 1980; Insley, 1982; Davies, 1984, 1985, 1987; Davies and Gardiner, 1985.) A grass sward, common to many amenity and agricultural tree-planting sites, is one of the worst ground covers in this respect.

Previous experiments have shown that tree growth was related to soil moisture and that unweeded trees showed foliar nitrogen deficiences. (Garwood and Williams, 1967), found that lack of nitrogen rather than soil moisture caused the cessation of grass growth under drought conditions.

In the north of Britain research with conifers on upland sites has shown that removing the weeds has a much smaller effect on growth and survival than in the south. This may be explained by the higher rainfall in the north, reducing the likelihood of moisture stress.

In order to investigate the effect of irrigation (simulating high rainfall) and nitrogen applications on trees growing either in weeds or in bare ground, an experiment was established at Alice Holt Research Station, near Farnham in Surrey. This experiment examined the effect on tree survival, growth and nutrient status of:

i) different types of ground cover
ii) regular irrigation to maintain a minimal soil moisture deficit
iii) nitrogen top dressings
iv) any interactions between these
v) the differences in response between a broadleaved and a coniferous species

METHODS

Experimental Design

The experiment was set up in the spring of 1986 on a heavy clay loam which was cultivated and drained. The two species used were Norway maple (*Acer platanoides*), and Sitka spruce (*Picea sitchensis*) which were planted as 1+1 transplants with four pairs of each species per plot, the weakest of each pair being removed after one season to ensure high survival. Plots were 4m x 4m with final tree spacing being 2m. Individual plots were isolated from each other by inserting vertical polythene barriers into trenches which were then back-filled with pea gravel and soil. A factorial design was used, with three main factors (listed below) giving 12 treatments laid out in a randomised block design with three replications.

Treatments

Ground Cover- three different types:

i) bare ground - maintained with paraquat and glyphosate herbicides applied as often as necessary

ii) grass sward - mown regularly to maintain a low vigorous sward

iii) clover - *Trifolium repens* "Huia"

Irrigation- with or without

The soil moisture deficit (SMD) was calculated weekly for each ground cover type using figures for potential (irrigated plots) and actual (non-irrigated plots) evapotranspiration (PE and AE) from the Meteorological Office, rainfall measurements taken at Alice Holt and amount of irrigation applied the previous week.

New SMD = Old SMD + (PE or AE) - Rainfall - Irrigation

Plots were irrigated when the SMD exceeded 30mm, to bring the SMD back to below 15mm.

Nitrogen application- with or without

Ammonium nitrate was applied as a top dressing fortnightly between March and August at a rate equivalent to 350kg N /ha/yr.

Phosphorous (P), potassium (K), and magnesium (Mg) were applied as basal dressing to all plots to ensure that there were no deficiences of these nutrients.

Assessments

Height and stem diameter were measured at planting (April 1986), in October 1986 and in July 1987. Foliar samples were taken in July 1986 for nutrient analysis of nitrogen, phosphorous, potassium, magnesium and calcium (N, P, K, Mg, Ca) levels in 1986 foliage. Soil moisture tension (SMT) was measured for each plot using a voltmeter connected to gypsum blocks at depths of 5 and 15 cm. These figures give an indication of the availability of the soil water to the trees (and weeds) in each plot. The experiment will continue for at least one more year.

RESULTS

Height and Diameter Growth

After nearly two seasons' growth there are clear differences in both height and diameter increment between the three ground covers, expecially between the bare earth and grass plots (see Table 1).

TABLE 1

Height and diameter increment April 1986 - July 1987

Species	Grass	Clover	Bare earth	Sig. level
		Height increment (cm)		
Sitka spruce	-7.7	39.7	35.5	$P<0.001$
Norway maple	-0.3	18.7	39.3	$P<0.001$
		Diameter increment (mm)		
Sitka spruce	4.26	7.14	8.97	$P<0.001$
Norway maple	1.34	3.40	5.80	$P<0.001$

Nitrogen application significantly ($P<0.001$) increased diameter growth of Sitka spruce but had no effect on height of either species. There was a ground cover x nitrogen interaction but only just significant: ($p=0.045$).

There were no significant effects of irrigation alone, although for both height and diameter of Sitka spruce the ground cover x irrigation interaction was significant ($p<0.05$), with growth in irrigated bare earth plots being less than that in non-irrigated.

Although the only significant ($p<0.05$) 2nd order interaction (ground cover x irrigation x nitrogen application) was that for diameter increment of Norway maple (see Table 2), there were some clear trends for the other parameters. Increments were consistently lower for irrigated, fertilised trees in grass than those in bare ground, without either.

TABLE 2

Table of means for Norway maple diameter increment (mm)

Nitrogen application	-N		+N	
Irrigation	-I	+I	-I	+I
Ground cover				
Grass	1.12	1.54	1.12	1.58
Clover	3.35	2.79	2.30	5.16
Bare earth	4.55	6.17	7.67	4.80

Foliar Nutrient Levels

Analysis of 1986 foliage showed that ground cover had a significant effect on foliar concentrations of all nutrients in both species except for P in Norway maple ($p<0.05$ for N, Mg in Norway maple and P in Sitka spruce, $p<0.001$ for all others).

Nitrogen application had a significant effect on levels of both N ($p<0.001$) and Ca ($p<0.05$) in Sitka spruce.

Irrigation appears to have reduced all nutrient levels in both species, except Mg in Sitka spruce. This effect was most marked for P and K in Norway maple (see Table 3). There was no significant interaction between fertilizer and irrigation effects.

TABLE 3

Foliar nutrient levels in irrigated and non-irrigated plots (% dry weight)

Species	Norway maple			Sitka spruce		
Irrigation	+I	-I	Sig. level	+I	-I	Sig. level
N	2.16	2.32	NS	1.32	1.45	NS
P	0.17	0.20	$p<0.01$	0.15	0.17	NS
K	0.48	0.61	$p<0.01$	0.58	0.59	NS
Mg	0.25	0.26	NS	0.06	0.06	$p<0.05$
Ca	0.92	0.90	NS	0.41	0.37	NS

There were significant interactions between ground cover and irrigation for N, Mg and Ca in Sitka spruce, between ground cover and nitrogen application for N and K in Norway maple and between ground cover, irrigation and nitrogen application for K in both species, although there are no clear trends in any of these at this stage.

Water Relations

Fig.1 shows SMT and rainfall for the summer months of 1986. Values for clover were very similar to those for grass and differences between irrigated bare earth and grass plots were negligible.

During 1986, irrigated plots were kept at or near field capacity all through the growing season. The equivalent of 81mm of rainfall was applied to bare earth and 122mm to grass and clover plots. Soil in non-irrigated plots remained at field capacity until mid-June following substantial rainfall in May. SMT in all plots was reduced after heavy periods of rain during July and August.

DISCUSSION

The results from this experiment show clearly that weeds growing around the base of a young tree had a drastic effect on its growth and nutrient status. The responses of a broadleaved and coniferous species were very similar.

Due to climatic conditions during this experiment it was not possible to investigate fully the effect of irrigation, as soil moisture deficits were not sufficient to put the trees under great moisture stress. Other experiments of this kind should be set up on those soil types more likely to induce moisture stress.

The results do indicate, however, that it was not possible to overcome the detrimental effect of a grass sward by irrigation and/or nitrogen application. This, in any case, would hardly be a practical solution to the problem of weeds. It is essential to ensure that the young tree is free from competition for water and nutrients so that it is vigorous enough to withstand the trauma of planting out and attack from other damaging agents The only way to do this is to kill the weeds around the base of the tree by chemical or other means, thereby eliminating competition above and below ground.

ACKNOWLEDGEMENTS

The work described in this report is carried out by the Forestry Commission under contract to the Department of the Environment.

REFERENCES

Davies, R.J. (1984). Weed control for amenity trees on man-made sites. Aspects of Applied Biology 5, 1984.

Davies, R.J. (1985). The importance of weed control and the use of tree shelters for establishing broadleaved trees on grass-dominated sites in England. Forestry 58 (2), 167-180.

Davies, R.J. (1987). Trees and weeds. Forestry Commission Handbook No.2. HMSO, London.

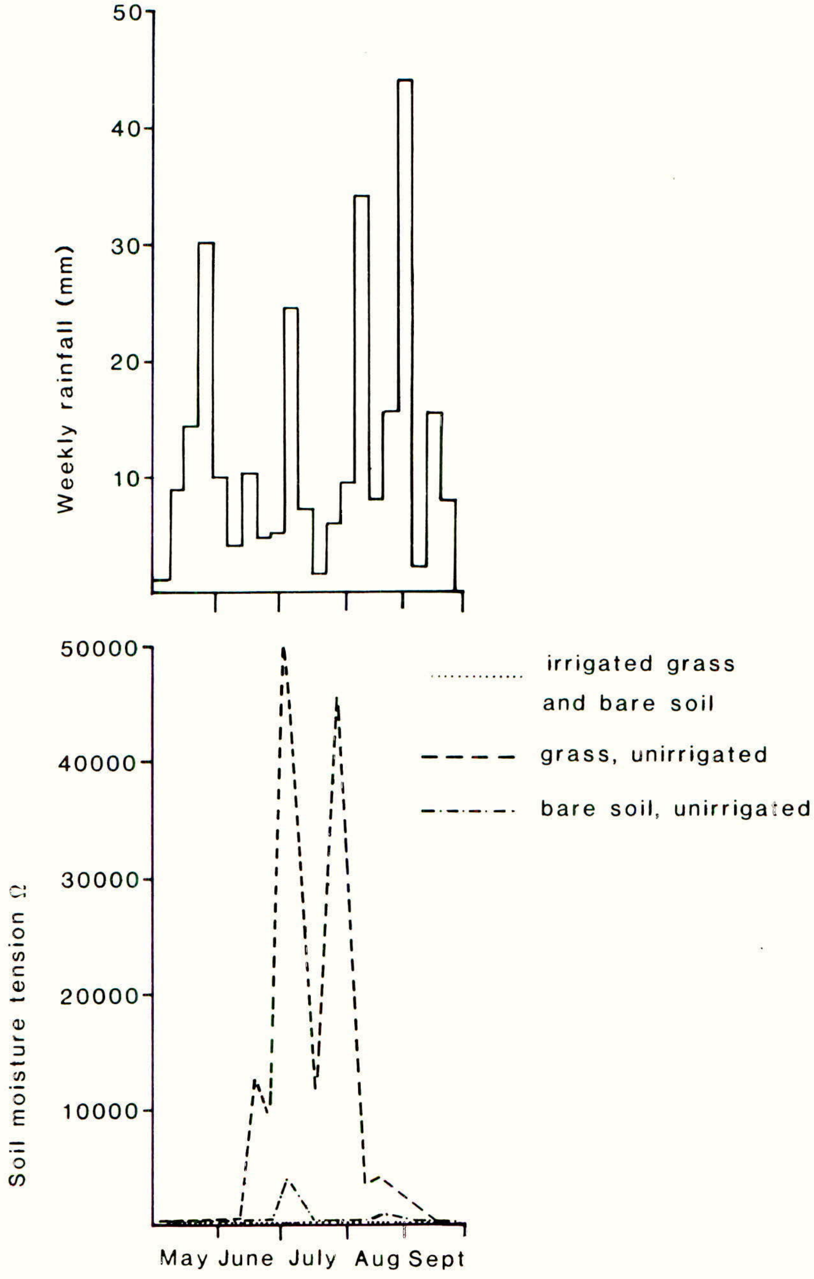
Davies, R.J. and Gardiner, J.B.H. (1985). The effects of weed competition on tree establishment. Arboriculture Research Note No.59. DoE Arboriculture Advisory and Information Service.

Garwood, E.A. and Williams, T.E. (1967) Growth, water use and nutrient uptake from the subsoil by grass swards. Journal of Agricultural Science 69, 125-130.

Insley, H. (1982). The effects of stock type, handling and sward control on amenity tree establishment. PhD Thesis, University of London.

Insley, H. and Buckley, G.P. (1980). Some aspects of weed control for amenity trees on man-made sites. Proceedings of the Conference on Weed Control in Forestry, 1980. Nottingham University, 189-200.

Figure 1. Soil moisture tension at 5cm depth & weekly rainfall in 1986



WEED CONTROL IN AFFORESTED AREAS

A. NIR

Weed Control Co. Ltd., Israel

Z. ARENSTEIN

Agan Chemical Manufacturers, Israel

ABSTRACT

Weed control trials were performed in afforested areas of Pinus halepensis and Cupressus sempervirens, both within the forest and in firebreaks. Imazapyr at 0.50-1.250 kg a.i./ha and sulfometuron at 0.075-0.188 kg a.i./ha were tested in different areas where effective control of annual weeds was achieved, including grass-weeds resistant to triazine herbicides. Imazapyr also controlled the perennial weeds Cynoden dactylon, Hyparrhenia hirta and Sorghum halepensis. Sulfometuron controlled S. halepensis only. Neither imazapyr nor sulfometuron,at any rate, were phytotoxic to the forest trees.

INTRODUCTION

The information presented in this paper is relevant to a subtropical climate with a rainy winter and dry summer and fall. In such a climate, in mid-summer, the ground is covered with dry vegetation which constitutes a fire hazard. At the beginning of the rainy season before planting time, annual vegetation of broadleaves and grasses covers the area. These weeds can interfere with planting and compete with the trees for moisture, nutrients and light,thus reducing the stand.

Chemical weed control in forests and in sites destined for afforestation is essential to eliminate weed competition, reduce fire hazard, overcome the lack of labourers for manual weed control and save expenses.

Trials performed during the years 1960-63 tested the pre- and post-planting application of the triazine herbicides, simazine and atrazine in forests of Pinus spp., Cupressus sempervirens and Eucalyptus spp. at a rate of 3.0 kg a.i./ha. This ensured sites free of winter annual weeds, both broadleaves and grasses.

The repetitive annual use of the triazines, mainly simazine and atrazine, caused the appearance of resistance in 7 annual grasses viz. Trachynia distachya, Phalaris paradoxa, Alopecurus utriculatus, Alopecurus myosuroides, Lophochloa phleoides, Lolium rigidum, Polypogon monspeliensis.

The above weeds began to infest the triazine treated areas. Initial coverage was approximately 10%, but this reached 80-90% during the years 1982-84.

In addition to the development of resistant annual weeds, perennial weeds which were not controlled by the triazines began to encroach on the treated areas, mainly in the firebreaks where there was no competition from the forest trees.

The objectives of the trials described below which were performed within the forest and in firebreaks were:-

(i) To find alternative herbicides to the triazines.
(ii) To test combinations of triazines with newer herbicides.
(iii) To test new herbicides for the control of perennial and annual weeds.

A) WEED CONTROL WITHIN THE FOREST (Trial 1)

MATERIALS AND METHODS

The trial was performed in a 2 year old forest planted to Pinus halepensis and C. sempervirens near Nazareth (named after Lord Balfour). Experimental design: randomised blocks with 3 replications. Plot size: 2 m x 30 m.

Weed population at time of treatment: T. distachya (Graminae), 3-5 cm high; Sylybum marianum (Compositae), 2 true leaves; Sinapis arvensis and Raphanus raphanistrum (Cruciferae), both at cotyledon stage.

Spray date: 9/12/1984. Spraying was carried out with a motorised knapsack sprayer equipped with a Flat-Jet TK-3 spray nozzle, pressure 280 KPa. Spray volume: 300 l/ha.

RESULTS

Weed control was assessed every 2 months and the final evaluations after 10 months are presented in Table 1.

TABLE 1

Effects of herbicides on annual weed control in 2 year old forest trees (P. halepensis and C. sempervirens), 10 months after application (Oct. 1985)

Herbicides	Rate a.i.(kg/ha)	Weed control %	Effect on trees
1) Simazine+fluazipop-butyl	2.5 + 0.25	50	1*
2) Terbutryne+fluazipop-butyl	2.0 + 0.25	60	1
3) Sulfometuron	0.075	90	1
4) Imazapyr	0.50	95	1
5) Unsprayed control	-	0	3

*According to scale of 1-10: 1 = no damage and normal growth,
10 = death of trees.

DISCUSSION

The combinations of simazine + fluazipop-butyl and terbutryne + fluazipop-butyl did not provide sufficient weed control for the whole winter season due to the emergence of T. distachya, during February-March, which later covered these plots.

Sulfometuron-methyl at a rate of 0.075 kg a.i./ha provided good control of broadleaved weeds and T. distachya, however Galium spp. began to emerge in patches i.e. was not controlled at this rate.

Imazapyr at a rate of 0.5 kg a.i./ha achieved the best results against broad-leaved weeds and T. distachya. A small number of Papaver spp. plants were observed to escape the effect of the herbicide.

In the unsprayed control plots, weeds of the Compositae family reached a height of 80-100 cms. The Pinus and Cupressus trees were pale in colour, water stressed and grew slower than in the other treatments in which they were dark green and actively growing.

B) WEED CONTROL IN FIREBREAKS

INTRODUCTION

Forests in Israel are surrounded by peripheral firebreaks and divided by internal ones as protection against fires during the hot and dry summer. The width of the firebreaks is 10-15 m and their length 3-15 km. In the winter, the firebreaks became covered with annual weeds as occurred within the forest and, in addition, with perennial weeds such as Hyparrhenia hirta, Sorghum halepensis and Cynoden dactylon.

As occurred in the forest, the prolonged and repeated use of triazines resulted in resistant weeds developing. In addition, perennial weeds became established.

B.1 ANNUAL WEED CONTROL (Trial 2)

MATERIALS AND METHODS

Location of the trial was in firebreaks in the Balfour Forest near Nazareth. Age of forest: 5 years. Forest species P. halepensis and C. sempervirens. The trial was carried out in 3 replications in a randomised blocks design. Plot size: 100 m x 10 m.

Weed population at time of treatment: dominant weed - T. distachya (Graminae), 3-5 cm height; Compositae, mainly S. marianum, cotyledon stage; S. arvensis and R. raphanistrum (Cruciferae), both at cotyledon stage.

Spray date: 30/12/84. Spraying was carried out with a motorised sprayer towed by a jeep. Sprayer equipped with a boom with T-Jet 8003 spray nozzles, pressure 420 KPa. Spray volume: 400 l/ha.

RESULTS

Assessment of weed control was carried out every 2 months. In Table 2 below, the final results 10 months after spraying are presented.

TABLE 2

Effects of herbicides on weed control in the firebreak and to forest trees (P. halepensis and C. sempervirens) on the border of the firebreak 10 months after application (Oct.1985)

Herbicides	Rate a.i. (kg/ha)	Weed control %	Effect on trees
1) Simazine+amitrole	3.0 + 1.0	40	1*
2) Simazine+metolachlor	2.5 + 2.5	60	1
3) Simazine+diuron	2.0 + 2.0	80	1
4) Sulfometuron	0.075	90**	1
5) Imazapyr	0.5	95***	1
6) Unsprayed control	-	0	2

*According to scale of 1-10: 1 = no damage, normal growth.
10 = death of trees.

** Galium spp. present.

*** Conyza spp. present.

DISCUSSION

The combination of simazine+amitrole was the standard treatment for many years in firebreaks until the appearance of resistant species.

The treatment simazine+metolachlor was effectively weed free for the first 3 months, however thereafter became infested with T. distachya.

The simazine+diuron treatment kept the plots weed free for the first 4 months but towards the end of the rainy season the plots became infested with Ammi visnaga.

Sulfometuron effectively controlled weeds until the end of the season, except for infestation with Galium spp. towards the end.

Imazapyr provided the best control of broad-leaved weeds and "resistant" grasses for the whole period, except for a few Conyza spp. which appeared in the summer.

In all the above treatments the forest trees bordering the plots were not damaged and were growing normally.

In the unsprayed control the annual broad-leaved weeds reached a height of 2 m and more, T. distachya reached a height of 80 cm. These weeds were dry and constituted a fire hazard and were therefore pulled out by hand in October. The Pinus and Cupressus trees were a slightly paler green than in the other treatments indicating their suffering from some stress.

B.2 PERENNIAL WEED CONTROL (Trial 3)

MATERIALS AND METHODS

The trial was carried out in a 15 year old forest of P. halepensis in the south of the country. No. replications: 2. Plot size: 500 m x 10 m.

Weed population at time of treatment: Annual weeds - T. distachya, Lophochloa phleoides (Graminae), 5 cm high; S. marianum, Notobasis syriaca (Compositae), 5 cm high; S. arvensis (Cruciferae), cotyledon stage. Perennial weeds which covered 50% of the area - H. hirta, 40 cm high, 70%; C. dactylon, 20%; S. halepensis, 10%.

Spray date: 21/11/85. Sprayer: towed by jeep and equipped with spray boom with T-Jet 8003 spray nozzles, pressure 420 KPa. Spray volume: 400 l/ha.

RESULTS

Over a period of 11 months observations were performed every 2 months to evaluate weed control and phytotoxicity. The herbicides tested, application rates and evaluations of control and phytotoxicity appear in Table 3.

TABLE 3

Effects of imazapyr and sulfometuron on control of perennial and annual weeds in firebreaks and phytotoxicity to P. halepensis on the border of the firebreak. Weed control evaluated after 11 months, phytotoxicity after 6 and 11 months

Herbicides	Rate a.i. (kg/ha)	Weed control (%) Annual	Perennial (1)	Perennial (2)	Perennial (3)	Phytotoxicity* Months 6	Phytotoxicity* Months 11
1) Sulfometuron	0.075	90	0	0	80	1	1
2) Sulfometuron	0.188	95	0	0	95	2	1
3) Imazapyr	0.625	98	95	90	80	1	1
4) Imazapyr	1.250	100	100	100	90	3	1
5) Unsprayed control	-	0	0	0	0	1	1

*Phytotoxicity according to scale of 1-10: 1 = normal and healthy,
10 = dead.

(1) H. hirta, (2) C. dactylon, (3) S. halepensis.

DISCUSSION

Sulfometuron - The lower rate achieved good weed control on annual weeds except for Galium spp. Amongst the perennial weeds the H. hirta and C. dactylon were not controlled at all, whereas the S. halepensis was 80% controlled. The higher rate achieved good control of all the annual weeds and S. halepensis, but C. dactylon and H. hirta were not controlled.

Imazapyr - Excellent control of annual weeds was achieved with the lower rate as well as effective control of H. hirta, the dominant perennial weed, and C. dactylon. S. halepensis was 80% controlled. At the higher rate, excellent control of annual weeds, C. dactylon and H. hirta was obtained. Good control of S. halepensis was achieved.

Phytotoxicity - In treatments where phytotoxicity was obtained it was limited only to the area of trees bordering the firebreak. Signs of phytotoxicity appeared 3-4 months after treatment and disappeared 10-11 months after spraying.

CONCLUSIONS

1) The trials within the forest and in the firebreaks show that imazapyr at the low rate of 0.5-0.625 kg a.i./ha provides a suitable alternative to the triazines and achieves good control of perennial weeds such as H. hirta and C. dactylon.

2) Sulfometuron at the low rate of 0.075 kg a.i./ha can also provide an alternative to the triazines for annual weed control, but is ineffective against perennials such as H. hirta and C. dactylon.

ACKNOWLEDGEMENTS

We are grateful to the Jewish National Fund, Yokne'am District, for permitting the use of their forests and firebreaks for our trials.

REFERENCES

Gressel, J. (1985) Prevention of the appearance of herbicide resistant weeds on roadsides. Phytoparasitica 13, 3-4, 248.

Nir, A.; Raz, A. (1985) Herbicide rotation at roadsides as a means of preventing triazine resistance in annual weeds. Phytoparasitica 13, 3-4, 248.

Rubin, B.; Ya'acoby, T.; Schonfeld, M. (1985) Triazine resistant grass weeds: cross resistance with wheat herbicide, a possible threat to cereal crops. Proceedings. British Crop Protection Conference Weeds 3, 1171-1178.

Ya'acoby, T.; Schonfeld, M.; Rubin, B. (1985) Triazine - resistant grass weeds and their response to herbicides. Phytoparasitica 13, 3-4, 232.

Ya'acoby, T.; Schonfeld, M.; Rubin, B. (1986) Characteristics of atrazine resistant biotypes of three grass weeds. Weed Science 34, 181-184.

SL 365 A GRANULE FORMULATION OF ATRAZINE, DIURON AND AMINOTRIAZOLE FOR LONG TERM WEED CONTROL ON NON-CROP LAND

D. CORNES, A.J. PIGOTT, P.J. RYAN

Ciba-Geigy Agrochemicals, Whittlesford, Cambridge, CB2 4QT.

ABSTRACT

Atrazine + diuron + aminotriazole (SL 365) in a ratio 4:15:10 formulated as a 5.8% a.i./kg granule was evaluated for total weed control on non-crop land in 1986/87. Annual and perennial grass and broad-leaved species were present in the seven trials initiated in the late spring of 1986. Excellent control of established weed species was recorded following a single application of SL 365 at 300 kg formulated product/ha. Assessments carried out in the following year also showed good residual weed control from this combination. SL 365 gave superior initial and residual weed control when compared to atrazine 4% granules and, controlled both Conyza canadensis and Epilobium montanum species found not to be controlled by atrazine following repeated application in previous years.

INTRODUCTION

Annually a wide variety of sites are chemically treated for the maintenance of weed-free areas where uncontrolled growth of weeds could present potential hazards or where regular mechanical control is impractical. For easy management of these areas the type of product used should be able to control a wide range of plant species and ideally provide weed control for up to 12 months from application. In some situations, where there is a limited water supply, the application method is also of importance. Traditionally, atrazine applied alone or in combination with other compounds, has been used extensively for the control of weeds on industrial sites. Particularly high rates are required for the control of established deep rooted perennials and repeated applications has encouraged the adaption of weed species and hence increased development of atrazine resistant weed populations (Bandeen et al, 1982).

SL 365 contains three active ingredients widely used in total weed control situations and which have complementary modes of activity. The wider use of products with more than one active ingredient can help to prevent the occurance of resistant weed types.

This paper reviews trials started in 1986 to determine the activity of SL 365 for total weed control.

MATERIALS AND METHODS

Seven trials were initiated to determine the activity of SL 365. SL 365, a 5.8% a.i./kg coated limestone grit granule, contains atrazine, diuron and aminotriazole in the ratio 4:15:10 and was compared to 4% atrazine granules at each site. The application rates were 300 and 450 kg formulated product/ha respectively and were applied by hand using a "pepper pot" dispenser.

Trial design and plot size were related to land availability and the distribution of weed species at individual sites. Four trial sites were of a randomised block design with three replicates and plots of 3 x 10 m, at three sites, however, the trials were unreplicated with plots of 3 x 15 m distributed at random within the trial area.

Weed control was assessed visually using a 0-100% scale by comparison to untreated plots, at three monthly intervals until fifteen months after application. Details of individual trial sites with respect to application date, site history and weed growth stage and population at application are presented in Tables 1 and 2.

TABLE 1

Site Details

Site	Location		Application Date	Previous Chemical Use
001	Cambridge	- Cement works	29:05:86	Nil
002	Cambridge	- Cement works	29:05:86	Nil
003	Kings Lynn	- Wood yard	29:05:86	atrazine (5 years)
004	Milton	- Refuse dump	18:06:86	Nil
005	Cambridge	- Airfield	12:06:86	Nil
006	London	- Dockland	10:05:86	Nil
007	Whittlesford	- Warehouse	10:07:86	Nil

RESULTS

Six grass weed species were encountered which were present at a range of growth stages at the time of application (Table 2). The two annual grass weed species were fully and rapidly controlled by SL 365 (Table 3), a level of control which was maintained in the second year. As with the annual grass species, the perennial grass species were also fully controlled in the year of application. Full control was maintained in the second year for A. stolonifera and P. trivialis. There is no second year assessment for H. lanatus as the species did not show significant re-growth in untreated plots. There was some slight re-growth of E. repens at one site apparently due to the uneven application of SL 365, at the other three sites full control was maintained.

The three annual dicot species; C. canadensis, Matricaria spp. and M. lupulina were all fully controlled by SL 365, (Table 4) as were three of the biennial dicots; A. sylvestris, C. vulgare and S. jacobaea. C. maculatum was not fully controlled with some re-establishment, amounting to 20% of that in the untreated, occurring in the second year.

Of the perennial dicots, A. rusticana was only controlled by SL 365 to a low level similar to that provided by atrazine. H. perforatum control by SL 365 increased in the second year relative to the first, and at 80% was acceptable although inferior to atrazine.

Both P. reptans and P. sterilis were not controlled by SL 365 and with the exception of P. reptans in the second year, also uncontrolled by atrazine. The remaining perennial dicot species; C. arvense, E. hirsutum, E. montanium and U. dioica were controlled both initially and in the year after application. SL 365 did have a significant effect on the woody shrub

R. fructicosus in the first year, however, a year after application the growth of the species appeared to be unimpaired.

TABLE 2

Plant size and population at application

Grass Weeds	Site	No. of Plants per m^2	Height (cm) From	To
Agrostis stolonifera	004	10	2	5
Elymus repens	001	250		35
	002	275	25	30
	004	50	2	10
	007	60	15	20
Bromus sterilis	001	120		30
Holcus lanatus	004	10	2	5
Poa annua	004	12		-
Poa trivialis	002	120	25	30
Broad-Leaved Weeds			**Height (cm) From**	**To**
Anthriscus sylvestris	002	18	45	65
Armoracia rusticana	001	15	20	30
	002	10	30	40
Cirsium arvense	004	10	5	10
Cirsium vulgare	001	55	35	40
	002	45	35	55
Conium maculatum	001	8	75	80
Conyza canadensis	003	630	2	4
	005	45	20	30
	007	20	10	15
Epilobium hirsutum	005	12	20	30
Epilobium montanum	003	8	2	4
	007	6	10	15
Hypericum perforatum	006	12	-	-
Matricaria spp.	004	12	2	4
	005	50	10	15
Medicago lupulina	004	35	2	10
Potentilla reptans	006	20	15	45
Potentilla sterillis	002	35		50
Rubus fructicosus	001			100
Senecio jacobea	004	5	2	5
Urtica dioica	001	110	40	45
	005	30	30	40

TABLE 3

Control of annual and perennial grass weeds with SL 365 (300 kg FP/ha) and atrazine (450 kg FP/ha)

Species	No. Sites	Mean % Control 43-104 DAT*		Mean % Control 326-440 DAT	
		SL 365	atrazine	SL 365	atrazine
Agrostis stolonifera	1	100	85	100	80
Bromus sterilis	1	100	60	100	70
Elymus repens	4	100	90	95	32
Holcus lanatus	1	100	90	-	-
Poa annua	1	100	85	100	100
Poa trivialis	1	100	100	100	100

*Days after treatment

TABLE 4

Control of annual and perennial broad-leaved weeds with SL 365 (300 kg FP/ha) and atrazine (450 kg FP/ha)

Species	No. Sites	Mean % Control 43-104 DAT		Mean % Control 326-440 DAT	
		SL 365	atrazine	SL 365	atrazine
Anthriscus sylvestris	1	90	0	100	0
Armoracia rusticana	2	57	47	47	25
Cirsium arvense	1	100	79	100	95
Cirsium vulgare	2	95	35	100	0
Conium maculatum	1	90	70	80	0
Conyza canadensis	2	97	99	100	100
Conyza canadensis *	1	100	0	100	0
Epilobium hirsutum	1	100	27	100	60
Epilobium montanum*	1	97	47	100	60
Epilobium montanum	1	100	20	90	0
Hypericum perforatum	1	60	0	80	100
Matricaria spp.	2	95	57	100	92
Medicago lupulina	1	100	65	100	100
Potentilla reptans	1	0	20	0	90
Potentilla sterillis	1	0	0	0	0
Rubus fructicosus	1	60	0	0	60
Senecio jacobea	1	100	40	-	-
Urtica dioica	2	95	77	95	77

* Species from site 003 with a history of atrazine use.

DISCUSSION

Applications of SL 365 were made rather late in the year, from May to July, to large well established weed species. This would usually be regarded as a less than optimum time for the application of granular herbicides due to the lack of soil moisture likely to be encountered. However, the low levels of soil moisture during the late spring and early summer of 1986 did not appear to impare the activity of SL 365. Initial symptoms included the characteristic bleaching of treated plants soon after application, and within 40-100 DAT the control of the majority of weed species present. This high level of control was maintained in the year after application with assessments 326-440 DAT confirming the residual activity of SL 365.

Site 003 had a history of atrazine usage during the previous five years. The apparent lack of control of C. canadensis and E. montanum during that period had allowed significant populations of these species to develop. SL 365, however, provided complete control of these species. In areas where prolonged atrazine use has resulted in the selection of particular atrazine tolerant species, the application of SL 365 is likely to provide effective weed control.

In the trials reported here, SL 365 was applied at the rate of 300 kg formulated product/ha, as the control of well established weed species was required. Further trials have been initiated during 1987 to evaluate the use of SL 365 at 100-200 kg/ha for the maintenance of weed free areas and the control of annual grass and broad-leaved species.

ACKNOWLEDGEMENTS

The authors would like to thank those organisations and members of their staff who co-operated with the trials and colleagues in Ciba-Geigy who helped with the work reported in this paper.

REFERENCES

Bandeen, J.D.; Stephenson, G.R.; Cowett E.R. (1982) Discovery and distribution of herbicide-resistant weeds. In: Herbicide Resistance in Plants. LeBaron, H.M. and Gressel, J. (Eds), Chichester: Wiley-Interscience, 9-19.

DISLODGABLE RESIDUES OF 2,4-D ON TURF

C. BOWHEY, H. McLEOD, G.R. STEPHENSON

Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada

ABSTRACT

Studies were conducted to determine the persistence, distribution and dislodgability of 2,4-D and related herbicides after application to turfgrass.

Increased rates of application resulted in increased amounts of dislodgable herbicide on the day of application. In all cases, residues declined to low levels after 10 days.

2,4-D, mecoprop and dicamba were more easily dislodged when applied as liquid formulations than when they were applied as granules.

Various extraction procedures were used to determine the persistence of the dislodgable, potentially dislodgable, bound and unavailable residues on turfgrass under shaded and non-shaded conditions. Total recoverable chemical remained fairly high throughout the experiment. Shading had no influence on the decrease in dislodgable residues. Recoverable residues in other fractions peaked at various times and then decreased. The majority of the herbicide was found in the potentially dislodgable fraction.

INTRODUCTION

In Ontario, 2.4-D has been extensively used for broad-leaved weed control in turfgrass areas such as parks, golf courses, homelawns and schoolyards. Recently however, public concern regarding the potential risk of human exposure through contact with the turf surface has led to the restricted or discontinued use of 2,4-D in many weed control programs. Field and laboratory studies were conducted to determine the persistence, distribution and dislodgability of 2,4-D on turfgrass (Thompson et al., 1984).

The studies reported here are an extension of those earlier investigations and were designed to investigate the effect of application rate, formulation and sunlight on the longevity and dislodgability of the phenoxy herbicide in the field. Included in the analysis are the residues of mecoprop and dicamba, two herbicides commonly found with 2,4-D in homelawn mixtures.

METHODS AND MATERIALS

Rate and Formulation Experiments

Field plots were established at the University of Guelph, Cambridge Research Station on an established mixed stand of Kentucky Blue/Annual Blue (*Poa pratensis*/*Poa annua*). Each plot measured two by twenty metres and the sampling area was one square metre. Untreated 0.5 metre wide buffer strips were present between blocks. Liquid formulations were applied using a 2 metre wide, 4 nozzle boom (Teejet A18004) at a pressure of 200 kPa. Granular applications were made with a Scotts fertilizer spreader. Plots were randomly assigned sampling times of 0, 1, 2, 3, 4, 8 and 10 days for the rate study and 0, 1, 2, 3, 4 and 9 days for the formulation experiment.

Sunlight vs. Shade

To determine the effect of sunlight on the persistence, distribution and dislodgability of 2,4-D, cores of turfgrass (12.7 cm diam X 2 cm depth) were cut from an established stand of Kentucky Blue/Annual Blue and placed on top of soil in 15 cm plastic plots. The turf was left to re-establish out of doors for 2 weeks and subirrigated at regular intervals. A frame was constructed and covered with dark screening to provide shade for half of the pots and the other half were left exposed to natural sunlight. All of the pots were protected from rain. The chemical (2,4-D amine) was applied using a trolley sprayer at 276 kPa, delivering 230 l/ha with a single flat fan nozzle (8002E). Sampling times were 0, 1, 2, 3, 4, 5, 9 and 14 days.

TABLE 1

Rates of application.

Study	Chemical	Rate Applied (kg a.i./ha)
Application rate		
Treatment 1	2,4-D	1.0
Treatment 2	2,4-D	2.0
Treatment 3	2,4-D	4.0
Formulation	2,4-D	1.0
	mecoprop	0.5
	dicamba	0.1
Sunlight/Shade	2,4-D	1.0

Determination of the Residue Fractions

Dislodgable residues

Determination of the dislodgable fraction on the field plots was achieved by vigorous mechanical scuffing of the turf's surface. New plastic bags were first fitted over the sampler's boots, then a 1,800 cm^2 piece of cheesecloth was moistened with distilled water and fitted over the plastic bags and fastened with an elastic band. A one metre plot was then scuffled across for 1 minute. To ensure complete coverage of the plot the scuffling was performed in two directions. The cheesecloth was removed from the boots and any unexposed area trimmed off and discarded. The samples were immediately placed into glass jars containing 200 ml acidic acetone and returned to the laboratory where they were shaken for 30 minutes. New plastic bags and cheesecloth were used for each plot.

Dislodgable residues on the potted turf were determined by vigorous hand wiping of the turfgrass with a dampened piece of cheesecloth held with disposable gloves. The cheesecloth was then immersed in 100 ml acidified acetone and placed on a mechanical shake for 15 minutes.

Potentially dislodgable residues

Immediately after the wiping procedure, the blades were clipped to the thatch layer, placed in 100 ml acidified methanol and shaken for 15 minutes to estimate the "potentially dislodgable residues". The methanol was decanted into boiling flasks and retained for further analysis.

Bound residues

To determine the amount of chemical bound to the cuticle layer the blades were subjected to two 15 minute washes with 100 ml hexane. The two hexane washes were combined into one boiling flask.

Residues within the leaf

Upon completion of the successive washes, the blades were finely ground in 50 ml acidified acetone with a Brinkman homogenizer. The filtered acetone was retained and the tissue discarded.

Preparation, Derivatization and Cleanup

After removal from the shaker, all samples were filtered through glass fibre filter paper and the solvent collected in round bottom boiling flasks. The volume of solvent was reduced on a rotovap to less than 1 millilitre. The samples were transferred to separatory funnels containing 100 ml acidic H_20 and a serial liquid-liquid partition (3 X 25 ml) with ethyl ether performed. The ether was collected and reduced on a rotovap and the samples transferred to test tubes with numerous methanol rinses.

2,4-D Samples

Samples containing 2,4-D only were reduced under nitrogen to a volume of less than 10 ml. The 2,4-D was derivatized to the methyl ester by adding 1/2 ml of 14% BF_3 methanol and heating in a 90^oC waterbath for 15 minutes. A serial liquid-liquid partition was performed in a 60 ml separatory funnel with 25 ml H_2O and 3 x 5 ml petroleum ether. The ether fractions were filtered through sodium sulphate and collectively collected in a clean test tube. An iso octane keeper was added and the volume reduced under nitrogen to 1 ml. The samples were eluted through a column containing 5 g 4% deactivated florisil and 2 g sodium sulphate with 25% ethyl ether/hexane as the eluding solvent. All solvents used were of high analytical purity (Distilled in Glass, Caledon Laboratories Ltd., Georgetown, Ontario, Canada). Analysis was performed on a Varian gas liquid chromatograph equipped with a Ni^{63} electron capture detector.

2,4-D + Mecoprop + Dicamba Samples

These samples were reduced under nitrogen to 1 ml and derivatized with 4 ml diazomethane. Samples were left for twenty minutes before removal of the diazomethane with nitrogen. A Hall detector was used to analyze the samples.

RESULTS

Application Rate Experiment

As expected there was an increase in the dislodgable fraction at Day 1 with an increase in application rate (Table 2). However this increase in dislodgable residues was greater than the proportional increase that would be expected with the increase in application rate. Regardless of the rate applied, residues decreased substantially by the end of one week to less than 1.0% of applied and to less than 0.2% by Day 10.

TABLE 2

Influence of application rate on dislodgable residues of 2,4-D.

Time (Days)	Application rate kg a.i./ha 1.0		2.0		4.0	
	%*	mg/m_2	%	mg/m_2	%	mg/m_2
0	2.59	2.59	3.45	6.90	4.65	18.60
1	3.34	3.34	3.44	6.88	3.27	13.08
2	1.63	1.63	2.26	4.52	2.45	9.80
3	1.93	1.93	2.11	4.22	2.52	10.08
4	1.49	1.49	1.85	3.70	2.98	14.80
8	0.53	0.53	0.26	0.52	0.28	1.12
10	0.08	0.08	0.08	0.16	0.16	0.64

* % of total chemical applied

Liquid vs. Granular Formulations of 2,4-D + Mecoprop + Dicamba

In this study, dislodgable residues at Day 0 were higher for all three herbicides formulated together and applied as a liquid than when the three herbicides were applied as a granular (Table 3A, 3B). However, at Day 1, dislodgable residues from the granular application were not lower than from the spray. From that point on, residues from both types of treatments showed similar rates of decrease to less than 2.0% at Day 4 and less than 0.2% at Day 9.

TABLE 3A

Dislodgable residues of 2,4-D, mecoprop and dicamba - liquid

Day	% of total chemical applied 2,4-D	mecoprop	dicamba
0	7.8	7.5	1.2
1	4.4	3.0	0.6
2	1.3	0.6	0.2
3	1.5	0.4	0.1
4	1.3	0.3	0.06
9	0.01	0.005	0.01

TABLE 3B

Dislodgable residues of 2,4-D, mecoprop and dicamba - granular

Day	% of total chemical applied 2,4-D	mecoprop	dicamba
0	2.4	2.7	0.4
1	5.9	5.2	1.1
2	2.3	1.4	0.3
3	1.1	0.6	0.05
4	0.4	0.2	0.02
9	0.2	0.01	0.04

Sunlight vs. Shade

Data for this experiment are reported in Tables 4A and 4B. The dislodgable fraction of 2,4-D (column A) shows a rapid decline over the 14 days for both shaded and non-shaded turf. The potentially dislodgable fraction (column B) in both shaded and non-shaded treatments showed a general increase to Day 3 and then a decrease with the non-shaded turf having less at Day 14. The cuticle bound residue (Column C) increased with time but was variable. The residues in the blades (Column D) increased substantially to Day 5 and then decreased as a result of metabolism or movement to underground portions of the plant. Total residues recoverable were fairly high throughout the experiment but lower in the non-shaded turf at Day 14.

TABLE 4A

Residues of 2,4-D recovered in various fractions of turfgrass - non-shaded field conditions.

Time (Days)	% of total chemical applied A*	B	C	D	Total
0	29.75	22.10	2.80	2.31	56.96
1	16.37	27.57	3.73	8.22	55.89
2	13.13	27.50	3.69	6.94	51.26
3	14.09	30.80	6.65	9.69	61.23
4	7.49	22.40	4.32	11.51	46.72
5	6.31	23.78	6.04	14.87	51.00
9	4.00	22.67	5.66	13.58	45.91
14	2.36	14.95	2.49	9.17	28.97

*A - dislodgable fraction
B - potentially dislodgable fraction
C - cuticular bound fraction
D - residue within the leaf

TABLE 4B

Residues of 2,4-D recovered in various fractions of turfgrass - shaded field conditions.

Time (Days)	% of total chemical applied A*	B	C	D	Total
0	28.30	25.24	2.93	2.07	58.54
1	15.81	32.93	5.98	8.71	63.43
2	16.96	35.97	3.93	9.91	66.75
3	17.50	32.64	3.09	5.99	59.55
4	9.66	26.30	4.05	8.96	48.97
5	7.19	24.79	4.31	12.04	48.33
9	4.06	20.65	4.71	10.60	40.02
14	3.56	23.67	5.64	9.45	42.32

DISCUSSION

In earlier studies, Thompson et al. (1984) concluded that there was a rapid decrease in dislodgable residues after application of 2,4-D to turfgrass. Mowing had only a small effect on the disappearance of these residues if the clippings were not removed. However, dislodgable residues were negligable after the first rainfall even if it occurred on the day that the turf was treated. Dislodgable residues were also lower when 2,4-D was applied as a granular than when 2,4-D was applied as a spray, particularly on the day of treatment. Thompson et al. also observed significantly faster disappearance of dislodgable residues in outdoor experiments than in indoor experiments - even in the absence of rainfall.

In the follow-up studies, the more than proportional increase in dislodgable residues of 2,4-D with increasing rates on the day of application, suggests the need for similar studies in areas where higher rates of 2,4-D and related herbicides have been applied for brush control. Data from the formulation experiment estabished that dislodgable residues of mecoprop and dicamba behave in a similar manner and show similar rates of disappearance as those observed for 2,4-D. 2,4-D was slightly more persistent on turf under shaded conditions outdoors than on turf in full sunlight. However, the effect of shade was not sufficient to explain the very rapid disappearance of dislodgable residues in outdoor versus indoor studies.

ACKNOWLEDGEMENTS

The authors thank Miss N. Swanson, Mr. D.G. Thompson and Mr. H. Braun for technical and analytical assistance. The research was funded in part through grants from the Ontario Ministry of the Environment, the Natural Sciences and Engineering Research Council of Canada and the Ontario Ministry of Agriculture and Food.

REFERENCE

Thompson, D.G.; Stephenson, G.R.; Sears, M.K. (1984) Persistence, distribution and dislodgable residues of 2,4-D following its application to turfgrass. Pesticide Science 15, 353-360.

SESSION 8B

WEED CONTROL IN OIL PRODUCING AND PROTEIN CROPS

SESSION ORGANISER MS C. M. KNOTT

POSTERS 8B-1 to 8B-8

USE OF DPX-A7881 FOR WEED CONTROL IN SPRING OILSEED RAPE IN CANADA

I.M. PARSONS

Du Pont Canada Inc, Mississauga, Ontario, Canada

ABSTRACT

There are over 13 million hectares of oilseed rape grown worldwide and of these, approximately 2.5 million hectares are grown in the three Prairie Provinces of Canada (Alberta, Saskatchewan, and Manitoba). Here *Sinapis arvensis* and *Thlaspi arvense* are major weed problems causing loss of crop yield and quality. DPX-A7881 at low dose rates as a post-emergence treatment is effective against these two species and other broadleaf weeds and is selective in the spring sown oilseed rape "double zero" cultivars commonly grown in Canada. Replanting trials have so far shown a good safety margin for other crops grown in typical rotation. The favourable toxicology, low dose rates, good crop tolerance and unique spectrum of activity make DPX-A7881 a promising tool for oilseed rape growers in Canada.

INTRODUCTION

Approximately twenty percent of the world supply of oilseed rape is grown in the Prairie Provinces of Canada, with the majority of the Canadian crop devoted to "double zero" varieties specifically developed to yield low levels of erucic acid (less than 5%) and glucosinolates (less than 30 micromoles per gram of oil free meal). (Canola Council of Canada. 1984) These varieties are commonly referred to as canola in Canada.

On the prairies, oilseed rape is spring sown and grown in rotation with cereal crops. Wild mustard (*Sinapis arvensis*) and stinkweed (*Thlaspi arvense*), are common weeds on the prairies. Their presence in the rape crop causes yield loss from competition. Ten *S. arvensis* plants per square metre can cause up to twenty percent yield reduction (Canola Council of Canada). The contamination of the weed seeds in the harvested seed also results in an undesirable loss of quality of the rapeseed oil and meal. This causes a significant earnings loss to the grower.

Oilseed rape is graded as one, two, three, or "sample reject" dependent on its degree of soundness and contamination levels in delivered seed. A twelve percent reduction of crop worth occurs if the delivered seed is downgraded from "one" to "two", another twenty-two percent reduction occurs from a downgrading of "two" to "three" and if the delivered seed is downgraded to "sample reject" there is another reduction of nineteen percent. This is a total loss of fifty-seven percent downgrading from a number "one" to "sample reject". Contamination of only five percent of *S. arvensis* seed in the delivered seed, results in the load being graded as "sample reject". This level would correspond to a weed infestation of about twenty plants per square metre (Canola Council of Canada, 1984).

Dockage for T. arvense and other weed seed contamination that can be removed from the delivered seed is based on the percentage contaminant in the sample. For example, if five percent "foreign" material is cleaned from the seed, then dockage would result in five percent reduction in the price for the delivered seed.

Some canola growers in Canada have turned to new triazine herbicide tolerant varieties such as Tribute or Triton, allowing the application of triazine herbicides in crop for control of these weed problems. However, these cultivars are lower yielding and late maturing, so there is a risk of crop loss due to early frosts. The oil content of these varieties is lower than average and may have a slight green tinge, making these varieties undesirable to the Canadian oilseed crushers.

In 1982, Du Pont scientists discovered 2-[[[[4-ethoxy-6-(methylamino)-1,3,5-triazin-2yl]-amino]carbonyl]amino]sulfonyl]benzoate, methyl ester, DPX-A7881, a member of the sulfonylurea class of herbicides, showing postemergence herbicidal activity on S. arvensis and T. arvense as well as selectivity in canola. (Hutchison et al., 1987) This research report summarizes the field evaluation of DPX-A7881 as a postemergence weed control herbicide in spring sown oilseed rape in Canada from 1984 to 1987.

MATERIALS AND METHODS

In the years 1984 through to 1986, randomized block design small plot efficacy trials, were established in the spring oilseed rape growing regions of the Prairie Provinces at 84 sites, where infestations of either T. arvense or S. arvensis were problems in production. DPX-A7881 was applied at dose rates of 5.0 to 124.0 grams active ingredient per hectare, plus surfactant at 0.2% v/v of total spray volume, using a four nozzle hand-held CO_2 sprayer equipped with Tee Jet 8002 nozzles delivering 110 litres per hectare spray volume at a pressure of 207.0 kPa. Applications were made from the pre-emergent stage of the canola to early bolting and with weed stages pre-emergent to early bolting. Weed control was assessed by a visual scoring of biomass reduction versus untreated plots on a scale of 0 to 100 percent.

Trials were also established at 21 sites in the years from 1984 to 1986 to determine whether DPX-A7881 would carry over into the next growing season. The agronomic practice in the Prairie Provinces is to apply postemergence broadleaf herbicides in late May to early June to crops, with the next crop not planted on that ground until the following April or May; an eleven month interval between application and recropping. DPX-A7881 was applied with truck mounted sprayers at rates of 30 and 60 g a.i/ha plus surfactant at 0.2% v/v in volumes of 110 l/ha of water at 207 kPa. Plot size was 14m x 45m. These plots were applied to the typical soils of the spring oilseed rape growing areas of the Prairie Provinces, those being black and dark brown soils (Agriculture Canada, 1977).

The following spring these sites were seeded with various crop species typical of the test area along with species known to be sensitive to DPX-A7881 and other sulfonylurea herbicides. The crops were sown perpendicular to the direction the treatments were applied the previous year. Effects on crop growth were assessed as a visual scoring of biomass reduction versus untreated plots on a scale of 0 to 100 percent.

Small plot randomized block tolerance tests were also carried out in 1986 at 18 sites using the most commonly grown cultivars of Canola. DPX-A7881 was applied at 5.0 to 30 g a.i./ha post-emergence.

RESULTS

Efficacy

Results of the efficacy trials were combined to give the mean percentage weed control and are shown in Table 1.

TABLE 1

The mean percentage of broad-leaved weed control given by DPX-A7881 applied postemergence at dose rates between 5.0 and 22.5 g a.i./ha (1984-1986)

Weed	Leaf Stage	% Weed Control (mean) Dose DPX-A7881 (g a.i./ha) 5.0	10.0	15.0	22.5
Thlaspi arvense	0-4	42 (7)	78 (9)	87(12)	91(13)
Thlaspi arvense	6	42 (4)	26 (3)	53 (5)	68 (4)
Sinapis arvensis	c-b	49(14)	71(18)	82(27)	90(17)
Galeopsis tetrahit	2-6			88 (4)	97 (3)
Polygonum scabrum	2-6	54 (2)	58 (3)	64(10)	82 (4)

Key: ( )= number of trials
c-b = cotyledon to bolting

DPX-A7881 has shown good control of *S. arvensis* at rates between 10.0 to 15.0 g a.i./ha. There is no evidence that weed staging has an effect on the control. *T. arvense* is more difficult to control in the field. This weed germinates throughout the early spring, thus application to a uniform weed staging is difficult. Our trials show earlier applications to be better than applications at the sixth leaf stage or later. Our observations in the field have shown that some *T. arvense* plants are not killed but are stunted and would generally be shorter than the average harvest cutting height for canola. The seed in this case would not be a contaminant in the harvested canola seed, and the plants left not competitive to the crop.

DPX-A7881 is also showing activity on other broadleaf weeds found in canola, such as *Galeopsis tetrahit* and *Polygonum scabrum*. Activity of DPX-A7881 was also reported for *Amaranthus retroflexus*, *Stellaria media* and *Polygonum persicaria*.

Recropping

The effect of applications of DPX-A7881 on crops sown 11 months after application is shown in Table 2.

TABLE 2

The number of trials where crops have shown more than 10 percent injury when sown 11 months after application at dose rates of 30 to 32 g a.i./ha or 45 to 64 g a.i./ha in trials established in 1984 to 1986

Crop Planted	Number of trials with greater than 10% injury	
	Dose DPX-A7881 (g a.i./ha)	
	30.0-32.0	45.0-64.0
Spring wheat	0 (15)	0 (17)
Durum wheat	0 (6)	0 (5)
Barley	0 (31)	1 (36)
Oats	0 (12)	0 (13)
Canola	1 (14)	1 (22)
Flax	0 (14)	0 (17)
Lentils	0 (14)	1 (15)
Alfalfa	0 (9)	2 (15)
Red clover	0 (4)	0 (4)
Peas	0 (9)	0 (9)
Mustard		0 (5)
Timothy	0 (3)	0 (3)

Key: ( ) = number of trials

Analysis of recropping trials in Western Canada is very difficult when faced with droughts, weed pressure and variable residual herbicides being used in cereal productions. Canola was injured at one site at both 30.0 and 60.0 ga.i./ha in 1987, while other more sensitive species were not affected. The parameters have not been assessed at this time as to the reason for this. However, canola is rarely grown two years in succession. Barley showed damage one year later at one site at the 64.0 gram rate. The damage was assessed at 20% as compared to the check. Lentils and alfalfa showed injury at one site at the 60.0 gram rate. The injury assessed was 35% for lentils and 20% for alfalfa.

The conclusions from these findings are dependent on the rate that the grower would apply for weed control and if there are distinguishable factors leading to any injury noted in the trials. If the final rates growers will use is approximately 20.0 g a.i./ha, then from these results, it would seem we have an approximate 3 times safety range to these sensitive crops grown 11 months after application of DPX-A7881.

Cultivar Tolerance

In the cultivar tolerance trials, DPX-A7881 applied post-emergence at rates of 10.0 to 30.0 g a.i./ha caused no visual damage to canola cultivars, Tobin, Westar, Global, Altex, Regent or Triton. Efficacy trials reported no visual damage to the list above plus, Pivot and Tribute. The cultivar tolerance of Westar and Tobin, the two major cultivars, are shown in Table 3.

TABLE 3

Yield increase from applications of DPX-A7881 in spring oilseed rape vs the untreated plots.

Variety	Number Trials	Percentage increase for the 20.0-30.0 (g a.i./ha) dose rates
Tobin	16	5.2
Westar	13	8.1

No reports of visual crop injury have been reported for rates up to 124.0 g a.i./ha applied postemergence to spring oilseed rape in Canada. In the 16 tolerance-to-yield trials established, there were no reports of visual crop injury from postemergence application of 20 to 30 g a.i./ha to the canola varieties grown. Across all varieties and rates from 10 to 30 grams the average yield increase over the untreated check was 6.6 percent. For rates of 20-30 g a.i./ha across all varieties tested the average increase was 8.1%. Westar showed an increase of 8.1% from applications of between 20-30 g a.i./ha and Tobin 5.2%.

DPX-A7881 does not show any tolerance problems for the varieties of canola tested.

DISCUSSION

DPX-A7881 has shown excellent selectivity when applied spring emergence to canola cultivars. When 20 g a.i./ha is used as the effective dose for weed control, *T. arvense* (up to the four leaf stage), *S. arvensis* and other broad leaved weed species, are controlled and/or suppressed in crop. At this use rate there is approximately 3 times safety factor to any residual chemical in the soil 11 months after application.

At present the only means available to the grower in controlling *S. arvensis* or *T. arvense* is to use cultural methods, grow lower yielding poorer quality triazine resistant cultivars and apply a triazine herbicide, or as a last resort, to take the land out of oilseed rape production. The last option is increasing in areas where these weeds are prevalent, although oilseed rape is an excellent cash crop for the farmer. DPX-A7881 is a new herbicide tool which may allow the oilseed rape producer to grow a cleaner crop free of contamination from *S. arvensis*, *T. arvense* and other weeds achieving higher yields of high quality oil and meal products.

REFERENCES

Agriculture Canada (1977) Soils of Canada 1, Brookfield: Renouf, USA inc.

Hutchinson, J.M.; Peter, C.J.; Amuti, K.S.; Hageman, L.H.; Roy, G.A. (1987) DPX-A7881: A new herbicide for oilseed rape. Proceedings 1987 British Crop Protection Conference - Weeds, (in press).

Thomas, P. (1984) Canola Growers Manual. Canola Council of Canada.

EFFECT OF HERBICIDES ON WEED CONTROL AND CROP YIELD IN WINTER OILSEED RAPE IN SOUTH-EAST SCOTLAND

D.H.K. Davies

East of Scotland College of Agriculture, West Mains Road, Edinburgh. EH9 3JG.

ABSTRACT

Trials in south-east Scotland with a wide range of herbicides from 1984-7 confirm that in the absence of high levels of volunteer cereals, significant yield benefits are seldom seen. A trial in 1986 examined the use of metazachlor at a range of rates and timings at a site with a very high broad-leaved weed population (249/m^2; 78.2% ground cover). There were improvements in yield, but there was no correlation with the level of weed control. The results confirm the lack of sensitivity of oilseed rape yield to high levels of many weed species, and suggest scope for reduced herbicide costs, but more information is required as to the effect of weeds on other aspects of crop production and seed quality.

INTRODUCTION

Winter oilseed rape has become an important feature of Scottish arable farming since 1982. However, in common with other subsidised arable crops, the profitability of the crop is being seriously affected by reduction in financial support, and other market trends, (Gardner, 1984). In such circumstances there is increased interest in the cost effectiveness of inputs to the crop.

This paper examines the effectiveness of herbicide inputs, which can often exceed 20% of variable costs of growing winter oilseed rape (Scottish Agricultural Colleges, 1986).

The Agricultural Development and Advisory Service (ADAS) in England and Wales carried out eleven yielded trials in harvest years 1979-81 to assess the efficacy of weed control of a range of herbicides (Ward, 1982). A yield increase was found in only four of these trials, and there appeared to be no consistent pattern of response. In trials undertaken in harvest year 1982 (ADAS, 1983), significant improvements in yield were found at four out of seven sites, characterised by high levels of volunteer cereals, _Alopecurus myosuroides_ or _Galium aparine_. Yield increases were again small at five sites harvested in 1983 (Orson, 1984), and, at a further nine sites harvested in 1984, a significant yield increase was found only at five sites. (Ward & Turner, 1985). Once again high levels of volunteer cereals characterised the improved yield sites. Where the oilseed rape was well established and populations of grass and broad-leaved weeds were low, yields were not significantly improved by the use of herbicides. This has been found by other workers(Lutman, 1984). In some cases yield reductions were noted. The competitive effect of volunteer cereals has been documented, and the ability of volunteer cereals, particularly in late sown or poorly established crops, to reduce yields has been frequently reported (Orson, 1984; Roebuck, 1984; Lutman & Dixon, 1985). The competitive effect of high levels of volunteer barley levels has been noted in Scottish trials (Davies & Wilson, 1987), but many Scottish farmers plough prior to drilling oilseed rape, which can reduce the problem. Many Scottish crops are apparently more seriously infested with broad-leaved weed species, notably _Stellaria media_, _Veronica_ spp., _Lamium_ spp., _Matricaria_ spp., _Capsella bursa-pastoris_, and _Myosotis arvensis_, and _Poa annua_.

Results mentioned previously would indicate that yield responses to the control of these species would be small.

This paper reports the results of tests between 1984-7 on a range of herbicide products on broad-leaved weeds and low levels of volunteer cereals in south-east Scotland, and of a trial in 1986 in which metazachlor was used at a range of rates to modify weed levels, in order to determine the effect on yield.

MATERIALS AND METHODS

Treatments were applied to 2m x 20m plots by Van der Weij knapsack sprayer calibrated to deliver 200 l/ha volume through Teejet 8003 nozzles at 210 KPa pressure in all trials. Pre-sowing treatments were incorporated by a shallow harrow on the drill. Treatments were randomized within three replicate blocks in each trial. Weed assessments were made by visual estimation of ground cover on a percentage basis, and weed numbers assessed in untreated plots by counts with 5 x 0.5m^2 quadrats. Plots were harvested by Claas Compact combine harvester, and yield calculated for grain at 9% moisture content.

1984-1987 Harvest Years Trials

A range of herbicide treatments were tested at four yielded sites in harvest seasons 1984, 1986 and 1987. Details of rates are given in Table 1; the materials tested alone or in mixture, were: benazolin/clopyralid, 'Benazalox', 35%WP; carbetamide, 'Carbetamex', 70%; carbetamide/dimefuron, 'Pradone Plus', 70% WP; cyanazine, 'Fortrol', 50% SC; metazachlor, 'Butisan S', 50% SC; propyzamide, 'Kerb 50 W', 50% WP; propyzamide/clopyralid, 'Matrikerb', 47.3% WP; TCA, 'NaTa'. 95% WP; tebutam, 'Comodor', 72% EC; trifluralin, 'Treflan', 48% EC; trifluralin/napropamide, 'Devrinol T', 24% EC.

The following winter oilseed rape varieties were sown at the sites:

(i) St Andrews, Fife; cv Bienvenu sown 22 August 1983
(ii) Cupar, Fife; cv Rafal sown 7 September 1985
(iii) Cupar, Fife; cv Rafal sown 27 August 1986
(iv) Chirnside, Border; cv Mikado sown 30 August 1986

1986 Metazachlor Trial

Metazachlor was applied at 500, 750 and 1250 g a.i./ha pre-emergence and post-emergence (growth stages given) (3-4 leaf crop stage) to winter oilseed rape cv Rafal at Cupar, Fife, sown 7 September 1985. The following weed species were treated pre-emergence and post-emergence: *Stellaria media* 4 leaf-stage (4 cm across); *Veronica arvensis* 2 leaf-stage; *Urtica urens* 2-4 leaf-stage; *Lamium purpureum* 2 leaf-stage; Volunteer barley 2 leaf-stage.

RESULTS

1984-1987 Harvest years trials

The volunteer barley and broad-leaf weed control at the four sites is given in Table 1, plus weed populations in the untreated plots. Only at site (ii) were weed populations high and consisted mainly of *Stellaria media*. Volunteer barley levels were moderately high at site (i), but insufficient to have a marked influence on yield (Table 2). Significant yield increases were noted at site (i) from two of the nine treatments, but these were not clearly associated with particular levels of weed control. At sites (iii) and (iv) only one treatment out of twenty-two gave a significant yield improvement to lower levels of weeds, but at site (ii) no significant yield response was found from control of weeds reaching 65% ground cover in the spring. Varying the rates of metazachlor and benazolin/clopyralid mixtures at sites (iii) and (iv) had a small effect on weed control (Table 1), but no effect on crop yield.

1986 Metazachlor Trial

There was a clear weed control response to the rate and timing of metazachlor treatment in this trial (Table 3). However, yield responses did not correspond with the variation in weed control (Table 3), although all treatments gave improvements at this weedy site.

TABLE 3

Effect of metazachlor rate and treatment timing on weed control in, and yield at 9% moisture of, a winter oilseed rape; harvest year 1986.

Timing and Treatment	Rate (g a.i./ha)	% ground cover Vol. barley	*S. media*	*V. arvensis*	*L. purpureum*	Total weed cover	Yield t/ha
Pre-emergence							
metazachlor	500	1.2	6.3	0	1.3	8.8	4.1
metazachlor	750	0.7	2.9	0	0.2	3.8	4.0
metazachlor	1250	0.6	0.3	0	0.1	1.0	4.0
Post-emergence							
metazachlor	500	1.6	26.7	0	3.5	31.8	4.0
metazachlor	750	1.6	9.3	0	3.2	14.8	4.0
metazachlor	1250	1.5	3.0	0	1.7	6.2	4.1
Untreated		2.3	63.7	6.2	6.0	78.2	3.8
Weed population/m² Untreated		(13)	(153)	(43)	(40)	(249)	
SED		0.5	4.4	1.0	1.4		0.16

DISCUSSION

The results from the 1984-1987 harvest years trials series reflect reports from earlier ADAS trials (Ward, 1982; Ward & Turner, 1984) that yield responses to herbicide use in winter oilseed rape are small where volunteer cereals and certain other weeds are not a problem. Even control of a 65.8% ground cover of weeds dominated by a high population of *S. media*, at one site, failed to give a significant yield increase, although yields improved a little. However, the yield improvements would barely cover the cost of the treatments tested.

A significant improvement in yield was found in the metazachlor trial in harvest year 1986, where the weed population reached 249/m² or 78.2% ground cover, again dominated by *S. media*. However, it made little difference what rate of metazachlor was used, and at what timing, as a reduction of weed cover to 1% ground cover by a 1250 g a.i./ha pre-emergence treatment gave no better yield response than a reduction to 31.8% ground cover of weeds by 500 g a.i./ha post-emergence treatment. At much lower weed populations, varying metazachlor and benazolin/clopyralid mixtures slightly affected weed control, but had no effect on yield differences at sites (iii) and (iv).

8B—2

TABLE 1

Effect of herbicide treatment on weed control in winter oilseed rape; trials in harvest years 1984,6 and 7

Timing and Treatment	Rate (g a.i./ha)	Weed % ground cover — Site: (i) Volunteer Cereal	(i) Broad-leaf weeds	(ii) Volunteer barley	(ii) Broad-leaf weeds	(iii) Broad-leaf weeds	(iv) Broad-leaf weeds
Pre-sowing							
TCA+trifl	1045+1104	2.5	2.0	0.9	12.0	-	-
trifl/napropamide	1680	3.0	2.5	0.6	4.3	-	-
Pre-emergence							
TCA+tebutam	1045+3600	0.2	6.5	-	-	-	-
tebutam	3600	-	-	0.0	10.8	-	-
metazachlor	750	-	-	-	-	0.6	3.6
metazachlor	1250	6.0	2.0	-	-	-	-
Pre-/post-emergence Seq.							
metaz then benaz/clopyr	500 t 175	-	-	-	-	3.6	1.7
Post-emergence							
metazachlor	1250	2.2	1.9	-	-	4.6	2.5
metaz+benaz/clopyr	375+175	-	-	-	-	0.2	5.9
metaz+benaz/clo	500+175	-	-	-	-	1.2	5.8
metaz+benaz/clopyr	500+263	-	-	-	-	0.2	2.3
metaz+benaz/clopyr	500+350	-	-	1.3	1.6	1.5	3.5
metaz+benaz/clo	1000+175	-	-	-	-	0.2	2.0
benaz/clopyr	350	17.7	7.4	-	-	-	-
benaz/clopyr/propyz	350+700	2.7	2.9	0.3	4.5	-	-
benaz/clopyr/carbet	350+2100	-	-	0.9	9.5	-	-
carbet/dimef	2100	-	-	0.7	13.4	3.0	5.5
cyanazine	500	-	-	-	-	1.1	2.6
cyanazine+propyz	500+700	1.0	0.5	-	-	-	-
propyzamide	700	-	-	0.0	22.4	6.5	6.1
propyz/clopyr	771	2.3	1.8	-	-	-	-
untreated		16.5	11.1	1.0	64.8	10.2	16.8
(Weed populations/m² untreated)		(82)	(54.5)	(20)	(256)	(106)	(60)

Key: trifl = trifluralin; benaz = benazolin; clopyr = clopyralid; propyz = propyzamide; carbet = carbetamide

TABLE 2
Effect of herbicide treatment on winter oilseed rape yield at 9% moisture content; trials in harvest years 1984,6 and 7

Timing Treatment	Rate (g a.i./ha)	Oilseed rape yield t/ha Site:(i)	(ii)	(iii)	(iv)
Pre-sowing					
TCA/trifl	1045+1104	2.7	3.9	-	-
trifl+napropamide	1680	2.0	4.1	-	-
Pre-emergence					
TCA/tebutam	1045+3600	3.2	-	-	-
tebutam	3600	-	4.1	-	-
metazachlor	750	-	-	4.8	4.8
metazachlor	1250	3.4	-	-	-
Pre/Post-em seq.					
metaz then benaz+clopyr	500 t 175	-	-	4.6	4.5
Post-emergence					
metazachlor	1250	2.9	-	4.4	4.6
metaz/benaz+clopyr	375+175	-	-	4.5	4.7
metaz/benaz+clopyr	500+175	-	-	4.7	4.5
metaz/benaz+clopyr	500+263	-	-	4.6	4.7
metaz/benaz+clopyr	500+350	-	4.0	4.6	4.5
metaz/benaz+clopyr	1000+175	-	-	4.6	4.7
benaz+clopyr	350	3.1	-	-	-
benaz+clopyr/propyz	350+700	2.8	4.1	-	-
benaz+clopyr/carbet	350+2100	-	4.0	-	-
Carbet+dimef	2100	-	4.0	4.6	4.6
cyanazine	500	-	-	4.9	4.6
cyanazine/propyz	500+700	3.1	-	-	-
propyzamide	700	-	3.9	4.8	4.8
propyz+clopyr	771	2.8	-	-	-
Untreated		2.8	3.8	4.6	4.8
SED		0.16	0.21	0.14	0.12

Key: trifl=trifluralin; metaz=metazachlor; benaz=benazolox; clopyr=clopyralid; propyz=propyzamide; carbet=carbetamide

These results confirm the lack of sensitivity of winter oilseed rape to high populations of many common weed species. Results from other sources mentioned earlier do show that certain weeds, such as volunteer cereals, A. myosuroides and G. aparine, are much more likely to cause significant yield depressions, but these weeds are not found at significant levels in all oilseed rape crops. There is apparently scope in many situations for reduced, or possibly less expensive, herbicide use in winter oilseed rape.

However, there is little experimental data and the effect of leaving such weeds on the costs and practical aspects of harvesting, and on factors such as disease levels in crops, seed quality, or weed levels in future crops in the rotation is uncertain. The need for such information is clear as farmers look to methods of reducing input costs.

ACKNOWLEDGEMENT

I wish to thank G.W. Wilson and M.C. Richards for assistance in the trials work and analyses.

REFERENCES

ADAS, (1983) ADAS Research and Development Reports; Sugar beet, oilseed rape and minor cash crops 1983. MAFF Reference Book 226 (83) Her Majesty's Stationery Office, Alnwick.

Davies, D.H.K.; Wilson, G.W. (1987) Report of weed control trials 1986. East of Scotland College of Agriculture, West Mains Road,Edinburgh.

Gardner, B. (1984) The economics of oilseed rape within the EEC. Aspects of Applied Biology 6, Agronomy, physiology, plant breeding and crop protection of oilseed rape, 1984, 1-9.

Lutman, P.J.W. (1984) The effects of weed competition on the growth and yield of oilseed rape. Aspects of Applied Biology 6, Agronomy physiology, plant breeding and crop protection of oilseed rape, 1984, 209-220.

Lutman, P.J.W.; Dixon, F.L. (1985) The effects of the timing of control of grass weeds on the yield of oilseed rape. Proceedings, 1985 British Crop Protection Conference - Weeds 1, 209-216.

Orson, J.H. (1984) The control of volunteer cereals in winter oilseed rape. Agricultural Development and Advisory Service - results - harvest years 1982 and 1983. Aspects of Applied Biology 6, Agronomy physiology, plant breeding and crop protection of oilseed rape, 1984, 179-184.

Roebuck, J.F. (1984) A review of ADAS trials for recently introduced specific grass weed herbicides for winter oilseed rape and the effect on yield of the timing of removal of volunteer cereals, 1983-1985. Proceedings 1985 British Crop Protection Conference - Weeds 1, 199-208

Scottish Agricultural Colleges (1986) Farm Management Handbook, 1986/7. Publication No. 168, The Scottish Agricultural Colleges, Cleeve, Perth.

Ward, J.T. (1982) Weed control in winter oilseed rape Proceedings 1982 British Crop Protection Conference - Weeds 1, 97-102

Ward, J.T.; Turner E.W. (1985) Annual grass and broad-leaved weed control in winter oilseed rape. Proceedings 1985 British Crop Protection Conference - Weeds 1, 223-230