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GRASS GROWTH RETARDANT USE AT SULLOM VOE TERMINAL, SHETLAND
1985 PROGRAMME REPORT

A report prepared for W.J. Cairns & Partners, 16 Randolph Crescent, Edinburgh, Environmental Consultants to BP Petroleum Development Limited as Operators of Sullom Voe Terminal

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SUMMARY

Plot trials set up in 1984 (Marshall, 1985) were continued in 1985 at Sullom Voe Terminal, Shetland. The objectives of the work were to further examine the effects of retardants on sown swards on the site and assess their likely practical use. Three retardants were examined in combination with mowing and fertiliser applications. The retardants were also applied using conventional and Controlled Droplet Application methods.

The results confirmed the greater part of those found in 1984. Applications in early April gave good results, as predicted in 1984. The retardants checked sward growth over a single cut in spring, giving reasonable height control to the end of August. Fertiliser application could, and perhaps should be, continued in combination with retardants. Mowing at some point in the season would be required to maintain good appearance, and would be best carried out close to spray application. Mefluidide encouraged clover but did not prevent flowering in ryegrass, a disadvantage where ryegrass is a major component of the sward. Maleic hydrazide reduced clover cover but not ryegrass, as had been anticipated in 1984. This compound performed better in 1985 and is recommended on balance as the best available to use in the situation. Paclobutrazol alone did not prevent flowering, but reduced grass head height. Its longevity of activity on the reclaimed substrates would lend itself to use where no cutting is allowed and where appearance is unimportant. The addition of mefluidide or maleic hydrazide to suppress flowering may be useful, but not essential for such sites.

If three cuts are regularly required during the season at Sullom Voe, then a retardant programme based on a single cut and spray may offer the saving of a single cut.

INTRODUCTION

Grass growth retardants have attracted considerable interest amongst amenity site managers over recent years (Shildrick & Marshall, 1985). As maintenance costs rise, chemical techniques may offer savings in costs, time and machinery. At present two compounds, maleic hydrazide (Regulox K, Burts & Harvey) and mefluidide (Mowchem, May & Baker), are commercially available and a third, paclobutrazol (Holdfast, ICI), is on limited commercial clearance. Previous experience (e.g. Marshall, 1983) has indicated the products have different properties, and are suitable for different situations as a result. Most work has been conducted on lowland amenity grassland and not on reclamation sites at the latitude of Sullom Voe.

Trials were set up in 1984 to examine these compounds on site to assess their likely effects and usefulness (Marshall, 1985). The main experiment was

repeated in 1985 to assess effects of repeated applications. Further work on mowing associated with spraying was set up and larger demonstration plots were layed out to further assess the practical use of retardants in a grass maintenance programme.

METHODS

Two experiments and an observation trial were laid out in April 1984 on an area adjacent to the Offsites Control Building. The area was on a stony substrate with almost no organic matter and no soil structure. In 1981 the area had been sown with seed mixture B:-

42%	Creeping red fescue
15	Chewings fescue
15	Brown Top Bent
15	Smooth stalked meadowgrass
10	Westerwolds ryegrass
1.5	New Zealand Huia White Clover
1.5	Kent Wild White Clover

In 1985 the main trial was repeated so that effects of repeated applications could be assessed. The effects of cutting before or shortly after spraying were assessed on the trial area used in 1984 to assess the effects of different times of retardant application. Some demonstration strips, cut and uncut were also layed out and two large areas sprayed with mefluidide using a CDA sprayer. Chemicals were applied through an Oxford Precision sprayer (OPS) or a Micron Herbi controlled droplet applicator (CDA). The OPS is pressurised by liquid CO_2 and operated at a boom pressure of 30 p.s.i. (2 bars). The 2m boom used had four nozzles with 8002 Teejets producing a flat fan spray pattern. At a forward speed of 1 m/s the sprayer gave a volume rate of 202.9 l/ha. The CDA sprayer has a battery operated rotary disk atomiser producing droplets of uniform size (c. 250 u). At a forward speed of 1 m/s the red nozzle gave a volume rate of 22.4 l/ha. While the CDA technique is attractive from the point of view of carrying considerably less water during spraying, CDA application of retardants is not yet cleared by the Pesticides Safety Precaution Scheme. Refinements of the application method might be suggested, e.g. low pressure hydraulic spray nozzles. However, the techniques used represent the two main application methods available.

Assessments of the trials were carried out by W Cowe and included composite sward heights, numbers of grass panicles, a score of plot appearance and an estimate of clover cover. Sward composition was estimated by EJPM recording species present in ten random throws of a 20 cm by 20 cm quadrat (0.04 m^2) per plot. Sward heights were measured with a simple sward stick, consisting of a pierced plastic plate (305 cm^2) which was lowered to rest down a metre ruler (Marshall, 1983). Five readings were taken in each plot every fortnight. Grass panicles were estimated for each species each month.

Plot appearance was assessed using a subjective "brownness" score. All assessments were made by W Cowe so they can be compared. The scores are on a 0-9 scale with 0 = all green and 9 = all brown. The percentage cover of clover in each plot was estimated by eye each month.

Data were analysed using analysis of variance with the GENSTAT package at the Agricultural Research Computer Centre, Rothamsted.

MAIN TRIAL. NC284 - 1985 PROGRAMME
THE EFFECTS OF THREE RETARDANTS APPLIED AT DIFFERENT RATES WITH TWO TYPES OF SPRAYER, WITH THEIR INTERACTIONS WITH CUTTING AND FERTILIZER TREATMENTS.

EXPERIMENT DETAILS

As in 1984 three chemical retardants were applied by OPS or CDA sprayer; plots were subsequently cut or left uncut and fertilised or not fertilised. The experiment was designed as a plaid with retardants and mowing treatments arranged at 90° for ease of implementation. Plots were then split in two receiving (+) or not receiving (-) fertiliser at random. Retardant treatments made on 11 April 1985 were as follows:

Code CONTROL	Retardant	Dose (kg (a.i.)/ha)	Applicator
C1	Maleic hydrazide (MH)	5.6	OPS
C2	Mefluidide (Mef)	0.4	OPS
C3	Mefluidide	0.8	OPS
C4	Paclobutrazol + mefluidide (Pac+)	0.75 + 0.15	OPS
C5	Paclobutrazol + mefluidide	1.5 + 0.3	OPS
C6	Maleic hydrazide	5.6	CDA
C7	Mefluidide	0.4	CDA
C8	Paclobutrazol + mefluidide	0.75 + 0.15	CDA

Mowing treatments (M1= mown to 5cm; M2= uncut) were carried out with a rotary mower on 26 April 1985, a fortnight after spraying. The treatment area was not otherwise mown in 1984 or 1985, except for discard areas between plots.

Fertiliser (+ and -) was applied by hand on 13 July 1985. The fertiliser was 15:15:15 N,P,K and was applied at a rate of 30 g/m^2.

Plot layout was as for 1984 (Marshall, 1985). Plots were 2m by 4m divided into 2m by 2m subplots for fertiliser. Treatments were replicated three times.

Application details:

Spraying was carried out on 11 April 1985 by E J P Marshall, assisted by M Bonnar. Chemicals were measured out on 10 April and mixed on site. Spraying began at 19.00 and ended at 21.00. The order of spraying was as above. The sward was wet; there was a light breeze of 5 knots (3-7) with an overcast sky. Air temperatures were between 4°C and 5°C. There were some spots of rain initially; thereafter it was dry, including most of the following day.

Spray problems were limited to uncertain deposition areas at the start and end of CDA-sprayed plots and to low rates applied to plots 105 and 106 as the spray mixture ran low.

RESULTS

Sward heights

Analyses of sward height data showed that there were significant carry-over effects from the paclobutrazol treatments in 1984 (Table 1, April 1985) There was winter kill and bird damage on some plots (1-18) which received fertilizer at ten times the advised rate in 1984. The retardants significantly affected height at all dates except 27 June, when weather may have affected assessments.

Interactions between mowing and chemical treatments were usually significant. Fertiliser had no effect on height until after application in July.

Table 1. Sward heights (cm) on mown and unmown retardant-treated plots. Data averaged over fertilised and unfertilised plots. NC284 - 1985.

Treatment	DATE 9/4	30/5	13/6	27/6	11/7	24/7	20/9
UNCUT							
CONTROL	7.9	11.3	10.6	6.6	11.5	9.4	12.0
C1 MH OPS	8.1	7.8*	8.2	6.2	7.7*	7.7	10.2
C2 Mef OPS	8.2	6.6*	5.9*	4.6	6.6*	7.7	11.3
C3 Mef OPS	7.0	5.6*	4.9*	4.4	5.5*	6.6*	11.8
C4 Pac+ OPS	4.7*	4.4*	3.4*	4.2	3.6*	4.0*	6.6*
C5 Pac+ OPS	4.2*	3.5*	2.7*	3.9	2.8*	3.3*	4.4*
C6 MH CDA	8.0	9.5	7.3*	8.5	8.7	8.0	11.6
C7 Mef CDA	7.1	6.5*	5.6*	5.7	8.1*	7.2*	11.9
C8 Pac+ CDA	5.0*	4.1*	2.9*	5.1	2.8*	4.1*	8.4*
CUT							
CONTROL	7.3	4.9	4.8	6.3	7.4	7.3	10.9
C1 MH OPS	7.7	4.5	4.1	4.1	5.2	5.9	10.0
C2 Mef OPS	6.4	4.5	4.7	3.4	5.6	6.6	11.9
C3 Mef OPS	6.7	3.8	3.1	3.6	4.7	5.4	11.2
C4 Pac+ OPS	5.8	4.0	3.4	5.2	3.8*	4.4	7.5*
C5 Pac+ OPS	4.5*	3.4	2.5	4.3	2.4*	2.9*	4.9*
C6 MH CDA	7.6	5.2	4.7	5.4	6.6	6.7	10.5
C7 Mef CDA	7.6	4.7	4.0	3.8	6.6	7.9	14.5
C8 Pac+ CDA	4.5*	3.3	2.9	4.1	3.3*	4.1*	9.5
Chemical effect:	***	**	**	N.S.	***	***	***
Mowing + chemical interaction:	N.S.	**	**	N.S.	N.S.	**	*
S.E.M.	0.63	0.97	1.05		1.26	0.73	0.73

(* = significantly different from controls)

There were highly significant carry-over effects from applications in 1984 on the plots treated with paclobutrazol. These plots were obviously still checked by the retardant in April 1985 when they received a second application.

On unmown plots the retardant treatments gave swards shorter than controls from May, though MH applied by CDA gave poor results. Significant height reductions persisted on paclobutrazol plots into September; effects were still significant on mefluidide plots to the end of July.

A single cut created an even sward, significantly shorter than uncut swards. Further growth checks were achieved by the paclobutrazol mixtures by the begining of July. In May and June there was apparently no advantage in mowing over retardant applications, in terms of height. Differences between OPS and CDA applications were minimal.

Panicle numbers

As in 1984 total grass panicle numbers were unaffected by fertiliser application but were significantly affected by mowing and the retardants. Panicle densities averaged over fertilised and unfertilised plots are given in Table 2. The data were variable, giving non-significant differences early on. A clearer picture of the effects on panicles was given by the maximum density of panicles, found by totalling the maxima for each recorded grass species.

Table 2. Grass panicle densities (No/m^2) on cut and uncut plots treated with grass retardants. Data averaged over fertilised and unfertilised plots. Maximum panicle densities were t-tested against their respective means. NC284 - 1985.

Treatment	DATE 27/6	11/7	5/8	20/9	Maximum
UNCUT					
CONTROL	21	687	43	52	687
C1 MH OPS	5	191	155	185	191*
C2 Mef OPS	7	280	348*	369*	369
C3 Mef OPS	5	145	159	167	167*
C4 Pac+ OPS	13	262	288*	294*	294
C5 Pac+ OPS	12	330	163	164	330
C6 MH CDA	6	401	120	131	401
C7 Mef CDA	9	452	325*	334*	452
C8 Pac+ CDA	4	253	212*	214	253*
CUT					
CONTROL	15	555	552	553	555
C1 MH OPS	7	273	245*	247*	273*
C2 Mef OPS	8	281	359*	361*	361*
C3 Mef OPS	8	149	236*	238*	238*
C4 Pac+ OPS	13	373	360*	360*	373
C5 Pac+ OPS	7	299	232*	233*	299*
C6 MH CDA	10	417	285*	285*	417
C7 Mef CDA	11	390	377*	377*	390
C8 Pac+ CDA	12	299	317*	321*	321*
Chemical effect:	NS	NS	*	NS	
Mowing + chemical interaction:	NS	NS	**	**	
S.E.M.	-	-	57.4	59.4	

* = significantly different from control

On uncut plots rapid lodging after July resulted in low panicle counts on control plots. Lowest panicle densities were found on MH, high dose mefludide and paclobutrazol mixture plots with little to chose between the treatments. In general poorer suppression of flowering was recorded in 1985. Of particular note was the difference in effect on ryegrass between the chemicals. There were no significant effects on meadowgrass heads and fescues were only slightly affected by fertiliser (fewer on fertilised plots). Ryegrass was prevented from flowering by maleic hydrazide and there were fewer heads on paclobutrazol plots treated at the higher rate (Table 3).

Table 3. Panicle densities (No/m^2) of Lolium perenne on sprayed plots on 5 August 1985. NC284.

Treatment	Control	C1 MH	C2 Mef	C3 Mef	C4 Pac+	C5 Pac+	C6 MH	C7 Mef	C8 Pac+	SEM
	145	23*	212	116	146	78*	82	158	125	29.3

Plot appearance

Plot appearance was scored on a subjective 0 to 9 scale (0=all green; 9=all brown). In addition, clover cover on each plot was estimated by eye on a percentage basis and the percentage bare ground in each plot was estimated by eye in July. Mowing did not affect plot scores until September, when cut plots were significantly better than uncut plots, which were also taller and more uneven. Fertilised plots had a better appearance (lower score) than unfertilised plots late in the season (Table 4.).

Table 4. Brownness scores on unfertilised and fertilised plots. NC284 - 1985.

	DATE					
	30/5	13/6	27/6	11/7	7/8	20/9
Fertilised	5.35	6.35	6.24	3.96	2.32	3.39
Unfertilised	4.96	6.32	5.78	4.31	3.57	4.48
S.E.	0.122	NS	NS	NS	0.125	0.088

Retardants had more impact on appearance than mowing or fertliser (Table 5). All plots had scores reflecting the poor growing conditions; there was little soil structure over the gravel substrate.

Table 5. Brownness scores on plots treated with different retardants. 1985. (0=all green; 9=all brown). NC284 - 1985.

Treatment	30/5	13/6	27/6	11/7	7/8	20/9
CONTROL	3.00	4.08	3.92	3.50	3.75	4.92
C1 MH OPS	4.75*	6.08	5.75	3.92	2.58	4.50
C2 Mef OPS	5.00*	5.08	4.67	2.67	2.67	3.17*
C3 Mef OPS	5.58*	6.33	6.00*	3.92	2.08	3.33*
C4 Pac+ OPS	6.42*	8.08	8.00*	6.08*	3.75	4.00
C5 Pac+ OPS	5.83*	8.17	7.83*	5.33	3.58	4.17
C6 MH CDA	3.75	5.00	5.25	3.08	2.50	4.42
C7 Mef CDA	5.67*	5.92	5.08	4.17	2.67	3.08*
C8 Pac+ CDA	6.42*	8.25	7.58*	4.58	2.92	3.83*
S.E.M.	0.561	NS	0.634	0.616	NS	0.337

* = significantly different from control

Initially, all except MH CDA treated plots had poorer appearance than controls. Particularly high scores were found on plots treated with paclobutrazol; these plots were unacceptable in June with a marked tufted but very short sward. In June the high dose of mefluidide also gave significantly poorer scores than controls, though by July appearance was better than control plots. In August and September there was little difference in scores, though mefluidide treated plots were perhaps better than controls with some compensatory vegetative (non-flowering) growth occurring later in the season.

Estimates of clover cover indicated no significant differences up to July, after which cover increased and significant effects of retardants, mowing and fertiliser were recorded. Greater clover cover was found on cut plots and on fertilised plots. Mefluidide plots had significantly more clover in September than controls and there were indications that paclobutrazol plots, particularly with CDA application, had more clover. Maleic hydrazide plots had consistently, though not significantly, lower clover cover (Table 6.).

Table 6. Clover cover (%) on retardant treated plots in September 1985. NC284.

Treatment	Control	C1 MH	C2 Mef	C3 Mef	C4 Pac+	C5 Pac+	C6 MH	C7 Mef	C8 Pac+	SEM
	29.4	11.0	52.9*	59.2*	38.3	45.0	16.8	63.3*	57.5*	7.35

The implications for continued annual applications are that clover would be reduced by maleic hydrazide but unaffected by mefluidide and paclobutrazol, the latter which affected clover growth earlier in the season.

Bare ground was estimated once only in July 1985. There was a highly significant effect with paclobutrazol (Table 7.), such that there was in excess of 30% bare ground in each plot.

Table 7. Percentage bare ground per plot in retardant treated plots in July. NC284 - 1985.

Treatment	Control	C1 MH	C2 Mef	C3 Mef	C4 Pac+	C5 Pac+	C6 MH	C7 Mef	C8 Pac+	SEM
	12.8	14.0	14.3	18.1	34.4*	40.0*	13.7	18.1	32.3*	3.60

Sward composition

Sward composition was estimated in April and at the end of July by recording rooted presence in ten 0.04m^2 quadrats per subplot. In April, just before retardant applications, there was obvious winterkill on those subplots numbered 1 to 18 which had been over-fertilised in 1984. During the course of the season these plots improved. April data indicated several statistically significant differences (Table 8.). First order effects were found for clover (Trifolium repens) and live mosses. Maleic hydrazide plots sprayed with the OPS had less T.repens than controls. There was also less clover on fertilised plots compared to unfertilised. Amounts of live moss were increased by cutting and by treatment with paclobutrazol mixtures and decreased by fertiliser application. There was a trend, not significant, for more Poa annua on paclobutrazol plots.

By July there were effects on amounts of ryegrass (Lolium perenne) with more on mefluidide and paclobutrazol plots than controls. The same significant effect was recorded with T.repens. There was significantly more live moss on cut paclobutrazol-treated plots than controls, though this was not found on uncut plots. This probably reflected the very open structure of the cut paclobutrazol plots, which had considerable amounts of bare ground available for colonisation. Fertiliser application reduced amounts of mosses, as found in April. There was some difficulty in identifying Poa annua and Poa trivialis in July, confused by retardant-induced changes in morphology. Analyses indicated more Poa on fertilised plots and the trend for greater amounts on paclobutrazol-treated plots was repeated, though it was not statistically significant.

Table 8. Average frequencies (as arcsine of percentage) of two species and live mossess in May and July 1985 on retardant-treated plots at Sullom Voe Terminal. NC284.

Treatment	L.perenne		T.repens		Moss	
	April	July	April	July	April	July
CONTROL	65.4	57.3	61.5	53.0	27.8	45.7
C1 MH OPS	64.5	42.5	45.1*	52.2	35.8	52.3
C2 Mef OPS	83.5	78.2*	74.8	78.7*	47.3	46.9
C3 Mef OPS	68.7	67.4	72.7	71.9*	27.8	55.0
C4 Pac+ OPS	73.9	72.9	63.1	66.1	63.5*	79.9
C5 Pac+ OPS	75.0	75.4*	76.9	78.0*	50.2*	69.7
C6 MH CDA	62.4	47.2	58.3	58.3	40.1	61.5
C7 Mef CDA	74.8	74.7	75.4	77.7*	29.9	52.1
C8 Pac+ CDA	70.1	70.8	83.2	80.3*	49.7*	72.7
S.E.M.	NS	5.97	5.36	5.36	6.64	NS

* = significantly different from controls

DISCUSSION

Assessments in April indicated a carry-over effect on growth where paclobutrazol had been applied at 1.0 and particularly 2.0 kg ha^{-1}. In 1985 lower rates of paclobutrazol were applied (0.75 and 1.5 kg ha^{-1}). In May there was obvious discolouration on all retardant plots. This effect continued on paclobutrazol plots and high rate mefluidide plots to late June. High rate paclobutrazol plots were probably unacceptable, particularly with the large amounts of bare ground between the small, almost minature, grass clumps. Mefluidide plots had improved appearance over controls later in the season.

There was an advantage in a cut associated with the application of the retardants in that a more even sward was created. Without a cut all retardants gave swards shorter than controls for a period of 8 weeks; paclobutrazol mixtures gave longest-lasting effects (into September) with high rate mefluidide lasting into July. Mowing gave shorter swards than uncut plots, though there was little difference between control and sprayed plots in terms of height. The advantages of the retardants were in appearance and in flower head suppression. Mowing gave little difference between paclobutrazol treatments. In terms of sward height there were no differences between maleic hydrazide and mefluidide, though high rate mefluidide was consistently best. Differences between applications with OPS hydraulic nozzles and CDA were minimal. Fertiliser was applied in July and only affected heights and appearance late in the season, enhancing both.

Clover cover was increased by cutting and by fertiliser. Mefluidide also increased clover cover, while maleic hydrazide had consistently low clover cover. While clover growth was retarded by paclobutrazol, growth later in the season gave cover values consistently greater than on control plots. Clover frequencies were significantly greater on mefluidide and paclobutrazol plots in July; maleic hydrazide plots had similar frequencies to controls. The enhancement of clover on reclamation sites may be of practical use for the improvement of soil nutrient status. If this is the case, mefluidide and paclobutrazol would be useful, while maleic hydrazide would not.

Ryegrass flowering was suppressed by maleic hydrazide but not mefluidide. In sown swards containing much ryegrass there are advantages in using maleic

hydrazide to check growth and flowering.

MOWING TRIAL. NC384 - 1985 PROGRAMME.
THE EFFECT OF MOWING ASSOCIATED WITH RETARDANT APPLICATIONS.

EXPERIMENT DETAILS

Using the plots used for Trial 1 in 1984 three retardants were applied by OPS to 2m by 2m plots on 11 April 1985. The same retardants were applied to the same plots as in 1984. In addition, plots chosen at random were either cut before treatment (20 March 1985), or a fortnight after spraying (26 April) or left uncut. Treatments were replicated three times and randomised within blocks. The treatments were as follows:

Code	Retardant	Rate (kg a.i./ha)
C1	maleic hydrazide	5.6
C2	mefluidide	0.4
C3	paclobutrazol + mefluidide	0.75 + 0.13
CONTROL		

Mowing was carried out on the following dates:

M1	20/3/85
M2	26/4/85
M3	Uncut

The plot layout was as follows

N.

24m

Rep.												
III	M3 C2	M1 C1	M3 C3	M1 C3	M1 CON	M1 C2	M3 C1	M3 CON	M2 C2	M2 C3	M2 C1	M2 CON
II	M1 C3	M3 C2	M1 C2	M3 C3	M2 CON	M3 C1	M2 C1	M2 C2	M2 C3	M3 CON	M1 C1	M1 CON
I	M2 C1	M1 C1	M1 C2	M2 CON	M1 C3	M2 C2	M3 C1	M3 CON	M3 C2	M3 C3	M1 CON	M2 C3

2m

Application details: as for Main Trial, NC284 (p.3)

RESULTS

Sward heights

Differences between the two mowing treatments were not significant from May onwards, though the uncut plots were significantly taller to August. By September there were few differences between treatments. Sward heights are given in Table 9. There was a significant carry-over effect from paclobutrazol treatments in 1984 when sward heights were measured in April by EJPM prior to treatment.

Table 9. Mean plate heights (cm) on plots treated with three retardants and cut before (M1), cut after spraying (M2) or left uncut (M3). NC384 - 1985. (N.B. assessment on 10/4/85 carried out by EJPM)

Mowing	Chemical	Date 10/4	31/5	13/6	27/6	11/7	25/7	20/9
M1 -	C1	37.0	30.7	23.3*	25.2*	34.0*	47.3*	98.7
mown before	C2	35.0	27.4*	27.0*	30.9*	45.0*	75.3	135.3
	C3	38.0	24.7*	21.7*	28.3*	27.7*	34.7*	107.7
	Control	39.7	38.5	42.3	45.1	60.0	76.3	140.0
M2 -	C1	68.3	28.7*	29.0	31.2*	31.3*	45.0*	114.3
mown after	C2	86.7	30.9	29.3	34.3*	39.3	61.3	142.7
	C3	46.3*	23.1*	20.3*	27.3*	30.7*	47.3*	90.3
	Control	69.3	39.7	39.3	44.3	50.3	61.3	143.3
M3 -	C1	59.0	45.1*	47.9*	42.4*	61.3*	59.3*	109.0
uncut	C2	47.0	32.1*	32.3*	30.5*	45.3*	71.0*	151.0
	C3	33.3*	22.9*	21.3*	24.3*	31.7*	35.0*	99.0
	Control	62.0	72.4	63.3	59.7	84.7	96.3	142.3
S.E.M.		5.61	3.62	3.79	3.30	4.49	4.40	NS

* = significantly different to controls.

On uncut plots paclobutrazol treatment gave shortest plots with mefluidide giving the next shortest until late July. On the cut plots the retardants gave shorter plots than controls, though the differences between the retardants themselves were not significant until July. Mefluidide plots were then similar to controls and by late July were taller than maleic hydrazide and paclobutrazol plots. This probably reflected the number of ryegrass heads in these plots and the lack of suppression of this grass by mefluidide.

Panicle numbers

There were no differences between the mowing treatments on total flower head numbers. However the three retardant treatments caused significant panicle suppression in comparison to controls (Table 10.). Best suppression was given by maleic hydrazide; mefluidide alone was slightly poorer than the paclobutrazol mixture in August. Analysing the effects on the three grasses in the sward, fescue, meadow grass and ryegrass, it was apparent that the retardants affected the first two similarly. However maleic hydrazide significantly reduced ryegrass flowering while mefluidide did not.

Table 10. Grass panicle densities (No. m^{-2}) on plots treated with three retardants. NC384 - 1985.

Treatment	Date 28/6	11/7		4/8	20/9
Grass heads	Total	Total	Ryegrass	Total	Total
C1	1	112*	22*	81*	81*
C2	3	440*	286	292*	302*
C3	4	320*	194	188*	192*
Control	7	812	244	447	449
S.E.M.	NS	78.7	43.6	27.1	26.8

* = significantly different from control

Plot appearance

Colour scores for grasses showed no significant difference between the mowing treatments. The retardants caused marked discolouration in May after application, though this had largely gone by mid-June when the retardant effect from mefluidide and maleic hydrazide would have been expected to have ceased. From late June the mefluidide plots had best colour and were significantly better than controls in August when brown flower heads contributed to the scores.

Clover cover was enhanced by mefluidide and paclobutrazol in June and July, though by September similar cover values were found on control plots. Maleic hydrazide adversely affected clover cover, as found on the Main Trial (Table 11.)

Table 11. Percentage clover cover on plots treated with retardants. NC384 - 1985.

Treatment	31/5	13/6	28/6	11/7	4/8	20/9
C1	7.8	5.9	7.6	12.2*	21.1*	46.7*
C2	31.0	32.3	33.9*	51.1*	70.0*	80.6
C3	33.2	36.4	45.9*	57.2*	60.6	78.3
Control	21.9	17.8	13.8	33.3	51.1	73.9
S.E.M.	6.18	6.59	6.01	4.29	3.84	5.00

* = significantly different from control

There was some evidence of a mowing effect on clover cover in July and August when there was less clover on plots mown after spraying. An interaction between mowing and retardants was also found in July. At that time on uncut plots, mefluidide and paclobutrazol had more clover than the control. There were no statistical differences between retardants and controls where mown after spraying. There was less clover on maleic hydrazide plots mown before spraying and more on paclobutrazol plots.

DISCUSSION

The mowing treatments, M1 and M2, did not give markedly different results in combination with retardant applications, indicating that timing of a cut associated with spraying was not critical in this situation. A cut at application had advantages in giving an even sward and a shorter sward for longer. Differences between the retardants were apparent from July, 12 weeks after application. All plots had initial discolouration associated with retardant stress. From July mefluidide plots were greenest, but also tallest as ryegrass suppression was inadequate. There was poor ryegrass suppression of paclobutrazol mixture plots, but good control of sward height. Clover cover was reduced by maleic hydrazide.

Each retardant had advantages and disadvantages. Mefluidide at 0.4 kg ha^{-1} lasted about 10 weeks after which grass growth gave a good colour. While flowering of other grasses was achieved, ryegrass heads were not suppressed, presenting a possible fire hazard. Maleic hydrazide gave good growth control, including head suppression of all grasses, but reduced clover cover. The paclobutrazol+mefluidide mixture had the longest lasting growth control, but had similarly poor effects on ryegrass to mefluidide alone. As clover is of importance in maintaining fertility in the reclamation situations on which the trials are located, maleic hydrazide is unlikely to be of use. However, if soil fertility is to be overcome by application of artificial fertiliser and ryegrass

is a major constituent of the sward, maleic hydrazide gave best sward control over the season. Paclobutrazol was active for longest and gave some carry-over to the following season when applied at 1.0 kg ha^{-1}. However by September the sward heights indicated no lasting effect at 0.75 kg ha^{-1}. A mixture of paclobutrazol with maleic hydrazide might seem a good compromise for use in the Sullom Voe site, but previous experience has indicated this mixture is unpredictable in its effect.

OBSERVATION TRIALS

Trial strips

A demonstration area was layed out adjacent to the Main Trial and treated on the same day, 10 April 1985, to show retardant effects over a larger area of ground. 2m wide strips, each 26m long, were treated with the following retardants:

Maleic hydrazide	5.6 kg ha^{-1} (ai)
Mefluidide	0.4
Paclobutrazol	1.5
Paclobutrazol + mefluidide	0.75 + 0.3
Paclobutrazol + mefluidide	1.5 + 0.3

An unsprayed control strip was layed out in the centre of the area. Half of the area was mown on 26 April and the whole area was fertilised on 15 July. At the end of July the uncut half supported many more grass heads than the mown half. The maleic hydrazide plot had best appearance, with few heads. The mefluidide plot also was short with good appearance, but ryegrass heads were present in some numbers. Paclobutrazol plots were short, with reasonable appearance and many shortened grass heads. Flowering was not suppressed, as found elsewhere (Marshall, 1983), though the panicles were stunted. The mixtures of paclobutrazol and mefluidide had generally poor appearance.

Large area trial

An area of approximately 0.25ha were treated with mefluidide at 0.4 kg ha^{-1} using the Micron Herbi CDA sprayer on 14 April 1985. Part of the area was mown on 28 April and the whole area was fertilised on 15 July. At the end of July casual observations on the trial area were made. In general there was little difference between the cut and uncut parts and there were uneven effects across the area. The result was generally disappointing, perhaps confirming that a rate of mefluidide of 0.4 kg ha^{-1} was too low.

DISCUSSION

As found in 1984 (Marshall, 1985), the mowing trial and the demonstration strips demonstrated that a cut associated with spraying gave shortest and most even swards. On the Main Trial however, the cut without retardants gave significant control of sward height. The main advantages in the retardants were the control of grass heads and the duration of a better apearance. The lack of suppression of ryegrass heads by mefluidide in comparison to maleic hydrazide was particularly marked in 1985. This was not observed in 1984, probably reflecting the later application that year. The higher rate of mefluidide gave consistently better results than 0.4 kg ha^{-1}. Overall control of grass heads was apparently poorer in 1985, though some differences between the years might be ascribed to different observers. In general the 1985 data confirmed that an application in April should be recommended at Sullom Voe.

Initial discolouration was recorded on the plots during the first month after spraying. Appearance was improved by fertiliser application in July 1985 and later in the year plots mown in April were better than uncut plots. The fertiliser effect was found in 1984, though the effect of mowing was not. Fertiliser had little effect on sward height and none on grass head numbers and could be continued in the grass maintenance programme in combination with retardants. The paclobutrazol mixtures gave extremely effective growth retardation, such that vegetative cover was poor and considerable amounts of bare ground were created. However, appearance of the paclobutrazol plots left much to be desired. Clover cover, which increased later in the season, was depressed by maleic hydrazide, enhanced by mefluidide and maintained on paclobutrazol plots. This effect, also noted in 1984, might indicate a reduction in clover with repeated use of maleic hydrazide, though frequencies of clover in July 1985 showed no significant differences to controls. Where nitrogen fixation by clover nodules is of importance, as is usually the case in reclamation situations, clover should be encouraged. The reductions in ryegrass frequencies on maleic hydrazide plots in 1984 were not repeated in 1985.

None of the retardant mixtures gave entirely ideal results, though certain advantages could be gained by using a retardant in a grass maintenance programme. Paclobutrazol, avialable on limited commercial clearance as "Holdfast" from ICI, was persistent in the gravel substrate of the trials area. The results indicated that the product would be useful where no cutting can be employed, such as around LPG tanks. The product may in the future be formulated as granules for ease of application. Mixed with mefluidide grass flowering could be suppressed, but the rates of paclobutrazol used were too high for more ornamental areas. Reduced paclobutrazol rates and an increase in mefluidide might be advantageous, and a mixture with maleic hydrazide might be tried. However, the paclobutrazol + maleic hydrazide mixture has proved unpredictable in the past (Marshall, 1983). The lack of ryegrass control by mefluidide could be a major drawback to its use. Likewise the effects of maleic hydrazide on clover were not beneficial. On balance the use of maleic hydrazide, or mefluidide at rates of about 0.8 kg ha^{-1} (not cleared for commercial use), would be best in open grass situations combined with a cut.

The maleic hydrazide treatment would offer some saving over a programme of three cuts during the season. Assuming a chemical cost of £60 ha^{-1} (£120 ha^{-1} for double rate mefluidide) and an application cost of £25 ha^{-1}, this still compares favourably with a mowing cost of £130 ha^{-1}. If one of three cuts is not carried out, a saving of about £130 ha^{-1} might be expected.

A suitable practical development would be to treat road verges and grass banks with maleic hydrazide or mefluidide. Commercial application methods should be used. It may prove difficult to achieve an even application on banks. An off-set nozzle (capable of treating up to 15m in one pass) mounted on a vehicle may provide a solution.

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