SESSION 4C

HERBICIDES IN FORAGE PRODUCTION

THE ROLE OF HERBICIDES IN INCREASING ENERGY YIELDS FROM U.K. GRASSLAND

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Summary. The output of Utilised Metabolisable Energy from grassland is calculated as 58 GJ/ha which is 60% of experimentally derived potential. Factors that limit the actual output from grassland are summarised and the possible contribution to output from improved grassland species is identified. Possible methods of establishing these preferred species are identified together with the role of herbicides in slowing the decline in productivity of swards and improving the establishment of sown species.

Grassland Output

The most recent data available from the Annual Agricultural Returns (June 1982) of the Ministry of Agriculture show there are 5.1 million hectares of permanent pasture (that is grassland 5 years of age or older), 1.86 million hectares of temporary grass (that is grassland under 5 years of age) and 0.2 million hectares of fodder crops. The total stock numbers that could graze this area or consume forage grown on the area consist of 3.25 million dairy cows, 1.397 million beef cattle and 8,627 million dairy or beef followers and 33 million sheep and lambs. The total livestock units, or cow equivalents are 10.610 million meaning that the average stocking density is 1.48 livestock units per hectare of total grass and fodder crops.

The Agricultural Development and Advisory Service of the Ministry of Agriculture have shown that a 600 kg Friesian Dairy Cow yielding 4,500 litres/annum at 4.0% Butter Fat and 8.8% Solids not Fat requires 48.9 giga joules (1 GJ = 1000 mega joules - MJ) of metabolisable energy (ME) per annum as total feed intake (MAFF, 1976). To obtain the ME obtained from grassland, defined as the Utilisable Metabolisable Energy (UME), the ME of the dairy compounds must be subtracted. Most calculations assume a 100% utilization of compound but this figure must be unrealistic; although it would be favourable for the justification to feed more compound feeding-stuffs and rely less on grassland for the total ME needs of a dairy cow, no figure for actual utilization of compounds is available, so 100% utilization is assumed. If the average consumption of compound is 1.0 tonnes/cow equivalent/annum, with each tonne contributing 11.0 GJ of ME, the actual contribution from grassland and forage crops is reduced by 11.0 GJ/cow equivalent/annum.

Similar calculations for other stock produce the following results, assuming 1 livestock unit requires 48 GJ of ME.

Stock	Number '000	Cow Equivalents '000	Total ME Needs million GJ	ME from Compounds million GJ	ME from Grass Forage million GJ
Dairy Cows	3,251	3,251	159	)	
Beef Cattle	1,397	1,048	50	) 92	308
Other Cattle	8,627	3,969	191	)	
Sheep & Lambs	33,049	2,342	112	4	108
Total :		10,610	512	96	416

Stocking rate and nitrogen usage usually hold the key to levels of ME produced, which had been similar on short and long leys and permanent pasture at similar stocking intensity and nitrogen usage (Fisons, 1964; Baker and Hope, 1964; Forbes et al, 1978). By increasing the Nitrogen level from a three year mean of 121 kg/ha to a mean of 196 kg/ha, the stocking rate was increased from a mean of 1.5 cow equivalent/ha to a mean of 2.2/ha with a yield of UME being increased from 31 GJ/ha to 57 GJ/ha (Forbes et al, 1978). No matter what species are present in fields, their level of production will be dependent on these husbandry factors.

Other factors over which the farmer has little or no control include rainfall, elevation, topography, wind speed, temperature and soil type. Irrigation is the only method of control over all these factors.

Grassland Species

Farmers do have control of the species they sew and, by the use of specific herbicides, they now have control over the competition from volunteer grasses and broad-leaved weeds.

The yield of a range of grass species (Cowling and Lockyer, 1965) was shown to vary by upto 50% at 4 nitrogen levels, with *Agrostis stolonifera* being the lowest yielding grass consistently over the 3 year life of the experiment and at Nitrogen levels of 0 to 390 kg/ha/annum. The highest yielding single species in these experiments was S.37 Cocksfoot followed by S.24 Perennial Ryegrass. The mixture of S.24, S.37 and S.48 Timothy tended to outyield the single species at all levels of Nitrogen. However, the response to Nitrogen was greater in all species than the difference between species. Subsequent work by Charles, 1972, Wells and Haggar, 1974 and Haggar, 1976 have shown that *Poa trivialis* acts as an inhibitor to the yield of *Lolium perenne* and that both *Agrostis stolonifera* and *Poa trivialis* have a yield potential of less than 73% of *Lolium perenne* under adequate fertility conditions. Wells and Haggar, (1974) also showed that *Lolium perenne* outyielded *Poa annua* by 21% and *Poa trivialis* by 42% but that a mixed sward containing all these species outyielded the *Lolium perenne* sward.

Conclusions drawn are:-

1. *Lolium perenne*, *Phleum pratense* and *Festuca pratensis* are desired species.

2. *Poa annua*, *Poa trivialis*, *Agrostis stolonifera*, *Holcus lanatus* and *Festuca rubra* are desired less due to lower yield potential, poorer palatability and digestibility.

3. Broad-leaved species depressed yields of established swards and reduced the establishment of sown species. All broad-leaved species, both annuals and perennials can be considered weeds with the exception of *Trifolium* species which have proved beneficial in terms of supplying up to 170 kg/ha/annum of Nitrogen - (Cowling and Lockyer 1965) and in improving the palatability and digestibility of pastures, leading to increased animal production.

Establishment and Maintenance of Desired Species

Pre-establishment:

On mixed grass/arable farms new grass leys can follow arable crops which allow the control of most weeds difficult to control in establishing swards, with the exception of volunteer cereals and *Avena* spp. and *Alopecurus myosuroides*, which can be controlled in new leys. In a grass to grass cropping sequence perennial weeds have to be controlled at the time of destroying the old sward. The use of the isopropylamine (IPA) salt of glyphosate at 1.4 - 2.2 kg/ha has proved successful at controlling the major perennial broad-leaved weeds *Rumex* spp. *Cirsium arvense*, *Urtica dioica*, *Pteridium aquilinum* and *Senecio jacobaea* and the major perennial weed grasses *Agrostis*

These calculations have had to assume average livestock unit figures for all classes of stock listed and exclude other users of grassland, including horses which would make a small but significant adjustment to the total ME produced from grass and fodder. To offset this calculation, there are 5.2 million ha of Rough Grazing in the United Kingdom and sheep output from this area has now been included. At a combined figure of 7.16 million hectares of grass and fodder, the total ME produced and utilized is therefore 58 GJ/ha.

Comparisons of yields from existing pasture with reseeded pastures by Monsanto have shown that output of 140-180 GJ/ha of total ME can be achieved when assessed by 7 cuts per annum made at 4-weekly intervals from April to September, with variations due to Nitrogen and rainfall levels together with the altitude, topography and soil texture at each site. Assuming a 60% Utilization factor to cover both grazed and conserved grass, it means that the grassland of the United Kingdom is producing less than 60% of its proven capacity. This is a very general statement but serves to focus attention on the need to increase grassland output. Sophisticated methods of refining livestock units and the metabolisable energy consumed and utilised from feeding stuffs have been published.

Effects of Increasing Grassland Output

The economic evaluation of increasing grassland output is discussed by Doyle, 1982 and will not be addressed. The farmer has four possible actions to take:-

1. To keep the same number of livestock on a reduced area, allowing extra land to be used for cash cropping.

2. To utilise the extra production as a substitute for purchased or home-grown concentrates.

3. To increase livestock numbers on a static area of grassland.

4. To reduce purchased fodder.

All these possibilities make the same assumption; that is that farmers either wish to or have to increase output or reduce costs. This assumption is certainly not true for all farmers due to a variety of reasons so it is essential to identify the farmers needs before constructing a programme of grassland improvement.

Each of the alternatives summarised can be costed and have been addressed in a paper by Elliott, 1981 on behalf of the British Grassland Society.

Factors Involved in Increasing Grassland Output

Experiments at research establishments (Mudd, C.H. - 1971) and on commercial farms confirm that grassland output is a complex and dynamic problem but certain features have to be correct before all swards are capable of high yields.

Drainage was identified by Forbes *et al*, 1980 as a limiting factor on 57% of the grassland on dairy farms with an even greater proportion of beef and sheep farms, notably the upland ones, suffering the same limitation. The results of inadequate drainage are to discourage preferred species and encourage species such as *Agrostis stolonifera* which is more flexible in its ability to survive under poor drainage conditions probably due to stoloniferous growth.

Fertiliser levels, notably Lime, Phosphate and Potash are all limiting. The same survey shows that 54% of temporary and over 60% of permanent grassland is growing in fields with a pH of below 6.5. The phosphorus index was below 2 on 33% of all fields and the potassium index below 2 on 36% of all fields. Given these figures it is surprising to see that dairy farms were able to gain 56% of their ME requirements from grass and beef farms about 80%.

stolonifera, Agropyron repens, Agrostis gigantea and Deschampsia caespitosa. The overall application of this chemical also controls the desired herbage species and annual plants, necessitating subsequent reseeding. The application of dalapon can produce selective control of Poa spp. but will not control typical perennating species. Paraquat applications will control young plants but will not control established weeds but with new cultivars of Lolium perenne showing resistance to this chemical selective post-emergence treatments may prove possible in the future.

During establishment:

There are no chemicals available to control established perennial weeds in newly sown leys but many chemicals will control the seedlings of perennial weeds. Rumex seedlings are susceptible to MCPA/MCPB and benazolin mixtures for example. Ethofumesate has proved of great value in controlling volunteer cereals, Avena spp. and Alopecurus myosuroides when applied early post-emergence to leys and also controls Poa spp. and Stellaria media, both of which are major weeds of newly sown leys. The problem of clover damage is paramount and the development of a method of introducing legumes into leys by slot-seeding has produced good results in terms of legume establishment but yield benefits have been minor upto the end of the year following their introduction. This probably indicates that legume species need to be established at the same time as grasses and thus limits the herbicides that can be used during establishment.

After Establishment:

Post-emergence herbicides that are safe to clover will control a wide range of annual broad-leaved weeds but most of these species will not survive after grazing. Products containing benazolin, 2,4-DB, MCPB and small amounts of 2,4-D and MCPA are safe to clover and are effective at controlling well-established annual dicot weeds. Where perennial dicot weeds have become established, a new technique of selective use of IPA glyphosate by wiper applicators is proving effective at controlling those weeds that are a minimum of 10-15 cm taller that the desired species. The technique is described by Norton, 1982 at this Conference. The range of applicators available could be used to apply other herbicides less active than IPA glyphosate against herbage species but effective against dicot species.

Having controlled patches of weeds by this technique, grassland output will not be increased until new species have been introduced. Current research into patch seeding at The A.R.C. Weed Research Organization is addressing this need but no results on yield benefit have been generated so far.

No selective control measures are available for unwanted perennial grasses in established leys and it is when these species dominate and desired species have been reduced to less than about 20% of the total population that the farmer has to reseed to increase the yield potential.

Conclusions

At a current total cost of £175 to £220 per ha., the decision to reseed will not be taken lightly. Where grass forms part of a rotation with arable crops the decision may be automatic at present but the trend is for farms to be split with continuous arable areas and continuous grassland areas.

Farmers must be limited by the ability of fertiliser, stock management and selective weed control to produce sufficient yield before reseeding becomes the preferred option.

New cultivars of wanted grass species respond to nitrogen better than most grass weed species so a greater investment in Nitrogen is justified; the higher use of Nitrogen produces greater competitive ability by the species that respond best; that is, the preferred species.

Herbicides do assist in producing a new sward dominated by preferred species; in extending the life of a productive sward and in controlling unwanted perennial grasses and broad-leaved weeds once a decision to renew has been taken.

Herbicides by themselves cannot produce a high yielding, palatable, highly digestive pasture out of poor worn-out pasture. The use of herbicides should support improvements in general husbandry including drainage, lime application, correction of nutrient deficiencies, controlled grazing and improved conservation techniques.

REFERENCES

Baker H.K. and Hope R. (1964) Grassland recording for dairy farms - a guide to profitability. Journal of the Farmers Club.

Charles A.H. (1972) Ryegrass Populations from Intensively Managed Leys, IV. Reaction to Management, Nitrogen Application and *Poa trivialis* L. in Field Trials, Journal of Agricultural Science, Cambridge, 79, 205-215.

Cowling D.W. and Lockyer D.R. (1965) A comparison of Different Grass spp. to Fertiliser Nitrogen and to Growth in Association with White Clover, I. Yield of D.M., Journal of the British Grassland Society, 20, 197-204.

Elliott J.G. (1981) The economic value of grass in the field. British Grassland Society Publication.

Fisons (1964) Fisons Grassland Recording Scheme. Fisons Agricultural Technical Information No.2.

Forbes T.J., Dibb C., Green J.O., Hopkins A., Peel S.(1980) Factors affecting the Productivity of Permanent Grassland. The Grassland Research Institute.

Haggar R.J. (1976) The Seasonal Productivity, Quality and Response to Nitrogen of Four Indigenous Grasses compared with *Lolium perenne*, Journal of the British Grassland Society, 31, 197-207.

M.A.F.F. (1980) Nutrient Allowances and Composition of Feeding Stuffs for Ruminants - Booklet 2987.

Mudd C.H. (1971) Yields of Natural and Artificial Grassland under 5 levels of Fertiliser Treatment, Proceedings of the 4th General Meeting of the European Grassland Federation, Lausanne, 1971, 69-72.

Norton A.J. (1982) The control of sugar beet bolters and weed beet by the height-selective application of the isopropylamine salt of glyphosate. British Crop Protection Conference - Weeds - in press.

Wells C.J. and Haggar R.J. (1974) Herbage Yields of Ryegrass Swards Invaded by *Poa* species, Journal of the British Grassland Society, 29, 109-110.

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BROAD-LEAVED WEED CONTROL AND CLOVER-SAFETY OF BENTAZONE MIXTURES USED IN UNDERSOWN CEREALS AND DIRECT-SOWN LEYS

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Summary. Trials over three years showed the mixture of bentazone + MCPB + MCPA to be safe to clover and give weed control equal to, or better than, the standard mixture based on benazolin. However it was found that the bentazone mixture was not safe when applied to clover at the spade leaf-stage. Weed control in direct-seeded leys was investigated with applications of bentazone + MCPB + MCPA, alone and in mixtures with cyanazine, applied during the winter and spring. The mixtures gave good weed control but clover safety was decreased when cyanazine was included. Further trials showed that a reduced rate of cyanazine (to 0.2 l/ha) in the mixture was safe to clover and gave better weed control than the standard when applied in the spring. MCPB, MCPA, cyanazine, Stellaria media, Veronica spp, Matricaria spp, benazolin.

INTRODUCTION

The sensitivity of clover to many of the commonly used cereal herbicides reduces the choice of herbicides for use in cereals undersown with grass/clover mixtures or direct seeded leys containing clovers. A herbicide mixture based on bentazone was reported to be safe to clover (Frost and Jung, 1974). Further work was aimed at developing an improved herbicide mixture, based on bentazone and including MCPB and MCPA.

Weed control in direct-seeded leys can be difficult to achieve due to the non-competitive nature of the crop. Clovers, which are important constituents of most seed mixtures, are particularly vulnerable to competition from weeds during ley establishment. The benefits of controlling weeds, especially Stellaria media, in this situation have been reported by Haggar and Kirkham (1981).

To control larger or overwintered weeds in direct-seeded leys, combinations of bentazone mixtures with cyanazine were evaluated for improved herbicidal activity and selectivity. This followed the successful work on bentazone + dichlorprop + cyanazine mixtures used in non-undersown cereals as reported by Woodcock and Staton (1982).

METHODS AND MATERIALS

Replicated trials were of a randomized block design with plot sizes of 30-40m^2. Treatments were applied by Van der Wiej and Oxford Precision knapsack sprayers at standard pressures and water volumes of 250-300 l/ha. The bentazone mixture used throughout was an aqueous solution containing 200 g bentazone + 200 g MCPB + 80 g MCPA a.i./l.

Weed control was assessed either (1) on a ground cover basis, expressed as a percentage of the untreated plots, or (2) by counting weeds present in a standard quadrat and expressing these as a percentage of the number on the untreated plots.

Clover safety was assessed either (1) as clover vigour, on a percentage scale, with the untreated equal to 100%, or (2) as clover survival, assessed as a percentage relative to the untreated, or (3) as clover survival, assessed by counting the numbers of clover plants in a standard number of quadrats and expressing this as a percentage of the number in the untreated plots.

RESULTS AND DISCUSSION

Replicated small plot and farmer usage trials were carried out between 1978-80 on spring barley crops undersown with clover and grass/clover mixtures. The formulated product of bentazone + MCPB + MCPA was shown to give similar or better weed control than the standard mixture of benazolin + 2,4-DB + MCPA. (Table 1).

Table 1

Control of various weeds in undersown spring cereals by two herbicides (%)

Weed species	No. of sites	Ground cover of weeds (%)	Herbicides Bentazone + MCPB + MCPA (5 l/ha)*	 Benazolin + 2,4-DB + MCPA (7 l/ha)**
Stellaria media	10	2-67	71	76
Matricaria spp.	3	5-7	99	43
Polygonum persicaria	5	2-40	76	51
Polygonum aviculare	3	2-9	53	53
Chenopodium album	4	5-25	88	88
Galium aparine	1	3	100	90
Sinapsis arvensis	3	5-30	98	98
Capsella bursa-pastoris	2	2-14	60	63
Spergula arvensis	2	14-30	47	50
Chrysanthemum segetum	1	3	58	8
Fumaria officinialis	2	2-6	59	55
Galeopsis tetrahit	1	5	83	80

* Formulated as product Acumen
** Formulated as product Legumex Extra

Marked superiority was shown on *Matricaria* spp. and *Chrysanthemum segetum*. Other species which were well controlled included *Chenopodium album*, *Galium aparine*, *Sinapsis arvensis* and *Galeopsis tetrahit*.

Stellaria media was the most widespread weed occurring in 10 of the trials and varied in size from seedling to flowering plants. This variation in weed size was responsible for the relatively low level of weed control obtained by both herbicides for this species. This was also the case for *Polygonum* spp.

To obtain an improved level of weed control, especially in some of the less well controlled weed species, further work was carried out in 1981 at earlier application times. The bentazone mixture was applied at the spade leaf-stage of the clover (at 2 sites) and at the 1-3 trifoliate leaf-stage (4 sites). At the earlier stage, the product was shown to have an unacceptably low level of selectivity (Table 2).

Table 2

The effect of application rate of bentazone, MCPB + MCPA on clover survival and weed control (%)

Rate l/ha	Clover survival		% Overall weed control	
	T_1	T_2	T_1	T_2
0	100	100	38	24
4	46		92	
5	32	100	97	94
6.5	23	100	97	97

Time of application:

T_1 = Clover spade-leaf

T_2 = 1-3 trifoliate leaf

Weed control in direct-seeded leys is often not possible within the present recommendations (which allows for applications up to the end of September), due to late sowing or slow emergence. This leads to larger, well established weeds which are difficult to control, Stellaria media being a particular problem. Three trials were carried out during the period 1981-82 to evaluate the formulated product of bentazone, MCPB + MCPA alone and in mixture with cyanazine for controlling weeds during the winter/early spring period.

Table 3

Effects of various herbicides applied at 3 different times on clover survival and overall weed (*) control (%)

Treatments	Rate l/ha	Clover survival Nov.	Jan.	March/April	Overall weed control Nov.	Jan.	March/April
		Application time:					
Untreated		100	100	100	-	-	-
Bentazone + MCPB + MCPA (a)	5	85	63	59	78	68	41
Bentazone + MCPB + MCPA (a) + cyanazine (b)	5+0.5	57	32	45	94	79	62
Benazolin + 2,4-DB + MCPA (c)	7	100	85	74	67	62	70
Mecoprop (600 g/l)	4.2	(6)	1	(24)	(83)	55	(67)
Linuron (300 g/l) (d)	0.83	41	21	42	52	40	37
No. of sites		3	2	3	3	2	3
( ) = 2 sites							

(a) Product Acumen
(b) Product Fortrol (containing 500 g/l cyanazine)
(c) Product Legumex Extra
(d) Product Rotalin

(*) Main weeds:
Stellaria media
Matricaria spp.
Lamium purpureum

Results from these trials (Table 3) were encouraging as, although there was a relatively high level of damage to the clover with the bentazone product + cyanazine, it did give good weed control especially when applied in November. All treatments generally gave some damage to the clover, especially mecoprop as would be expected. From these trials the timing which was most selective to the clover was November. However, it should be noted that the later timings would have been affected (severely in one case) by the very extreme winter weather of 1981/82. The levels of weed control with all treatments generally decreased with time. This was probably due to the increased weed size or hardiness of the weeds. The bentazone mixture gave relatively good weed control and this was improved markedly by the addition of cyanazine so that this mixture gave the best overall weed control.

Further trials on direct-sown leys were carried out in spring 1982 to evaluate the addition of rates of cyanazine lower than 0.5 l/ha. In three trials, where clover was present at the 2-4 trifoliate leaf-stage, the addition of cyanazine gave no clover thinning and only a relatively small reduction in clover vigour (Table 4).

Table 4

Effect of various herbicide mixtures, applied in April 1982, on clover vigour and percentage weed control 6 weeks after application

Treatments	Rate l/ha	Clover vigour	Stellaria media	Veronica spp.	Matricaria spp.	C. bursa-pastoris	Papaver rhoeas
1)Bentazone + MCPB+MCPA(a)	5	96	59	85	83	70	90
2)(1)+cyanazine (b)	5+0.2	84	79	85	88	79	99
3)(1)+cyanazine	5+0.3	82	84	86	90	90	98
4)(1)+cyanazine	4+0.3	86	69	81	80	73	91
5)Benazolin + 2,4-DB+MCPA(c)	7	90	76	59	64	73	93
No. of sites		3	6	2	4	1	1
Weed size, diameter/leaves			20-40 cm	20-30 cm	4-10	8-10	4-6
Ground cover, %			42	14	29	16	20

(a) Product Acumen
(b) Product Fortrol (containing 500 g/l cyanazine)
(c) Product Ley Herbitox

Weed control on six trials was improved by the addition of cyanazine especially of Stellaria media and Capsella bursa-pastoris. There were only marginal differences in overall weed control between the 0.2 and 0.3 l/ha rates of cyanazine.

Further work on the bentazone products, alone and in mixtures with cyanazine, will be carried out to establish selectivity and weed control at various timings in 1983.

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REFERENCES

Frost, A. J. P.; Jung, K. U. (1974). Some results with bentazone mixtures with phenoxyalkanoic herbicides for use in cereals undersown with clover. Proceedings 12th British Weed Control Conference, 157-162.

Haggar, R. J.; Kirkham, F. W. (1981). Selective herbicides for establishing weed-free grass. Weed Research, 21, 141-151.

Woodcock, P. M.; Staton, J. S. (1982). The control of broad-leaved weeds in cereals with combinations of bentazone, dichlorprop and cyanazine. Proceedings 1982 British Crop Protection Conference - Weeds (in press).

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TRICLOPYR FOR CONTROLLING CERTAIN PERENNIAL BROAD-LEAVED WEEDS IN GRASSLAND

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Summary. Triclopyr, a systemic growth regulator herbicide, was examined in grassland for control of *Urtica dioica* and *Rumex spp.* and in hedgerows and waste land for control of *Rubus fruticosus*, *Ulex europaeus* and *Sarothamnus scoparius*. The results show that effective weed control of *U. dioica* was achieved with 960 g a.i./ha triclopyr. *Rumex obtusifolius* and *R. crispus* required 1440 g a.i./ha triclopyr and may need a repeat application. A useful effect was also noted on *Cirsium arvense* and *Ranunculus repens*. Trials confirmed that triclopyr gave effective control of *R. fruticosus*, *U. europaeus* and *S. scoparius* at 460 g a.i./ha. Keywords, Urtica dioica, Rumex spp. Ranunculus repens, Rubus fruticosus, Ulex europaeus.

Résumé. Le triclopyr, un herbicide systémique type-phytohormone, a été évalué sur prairie pour la destruction de *Urtica dioica* et *Rumex spp.* et dans des zones non-cultivées et comme debroussaillant pour la destruction de *Rubus fruticosus*, *Ulex europaeus* et *Sarothamnus scoparius*. Les résultats ont démontré que 960 g m a/ha de triclopyr assuraient une très bonne destruction de *U. dioica*. Pour *Rumex obtusifolius* et *R. crispus* 1440 g m a/ha de triclopyr furent necessaires, quelquefois suivi d'un deuxième traitement. En plus, un effet secondaire sur *Cirsium arvense* et *Ranunculus repens* à été noté. 460 g m a/ha de triclopyr étaient suffisants pour donner une très bonne destruction de *R. fruticosus*, *U. europaeus* et *S. scoparius*.

INTRODUCTION

Broad-leaved weeds can have a serious and damaging effect on pasture production. *Urtica dioica* can smother and kill considerable areas of valuable grass and may necessitate more frequent re-seeding. *Rumex spp.* invade many long term leys and if left untreated will also reduce pasture productivity and quality. Similarly, *Rubus fruticosus* will smother hedges and invade the edges of fields taking up valuable grazing, while *Ulex europaeus* and *Sarothamnus scoparius* may often encroach on marginal and upland fields seriously reducing their productive capacity. On many farms, maximum grass production from these areas is vital to the economy of the whole farm and re-seeding costs can be high, both in terms of new inputs and lost grazing.

Triclopyr* is a systemic growth regulator herbicide discovered in the United States of America and developed in the United Kingdom originally for scrub and weed control in forestry (Gilchrist, 1980; McCavish, 1980). This work showed useful effect on *R. fruticosus*, *U. europaeus* and *S. scoparius* which often occur on farms.

It was therefore decided to investigate its potential for wider use in agriculture, particularly for control of the common and persistent grassland weeds *Rumex spp*. and *U. dioica*.

The results reported here are from a programme of trials carried out over two years.

METHODS AND MATERIALS

The weed control results are reported for 5 fully replicated (4 replicates) small plot trials in grassland and four non-replicated trials on hedgerows or railway embankments. The size of plots varied from 10 to 15m x 2m depending on the prevailing weed density.

All weeds were sprayed when actively growing and, in the case of grassland, after cutting or grazing.

The replicated trials were sprayed using a small plot boom sprayer fitted with fan jets and applying 250-330 l/ha water at 3.0 bars pressure. Three of these trials on *Rumex spp*. received a second treatment 12 months after the first spray. Non-replicated trials were sprayed by knapsack sprayer using 1000 l/ha water.

In all trials an e.c. formulation of the ethylene glycol butyl ether ester was used. In the first year the formulation contained 480 g of triclopyr/l and in the second year 240 g/l. As a standard a Ministry of Agriculture 'Approved' treatment of 2,4,5-T ester (500 g a.i./l) was included in all trials except in two trials where asulam (400 g a.i./l) was used.

Assessment of weed control was either by weed counts per plot or by visual weed assessment, using the European Weed Research Committee (EWRC) scale, 1 = 100% control, 5 = 87.5-80% control (just satisfactory), or a scale of 0-100% (Trial 5).

Where weed control data has been analysed statistically square root transformations were used. For clarity, detransformed data are given in the tables.

Further details for each site are given in Table 1.

* Triclopyr for agriculture is marketed under the name 'Garlon' 2. 'Garlon' is a trade mark of Dow Chemical Company Limited.

Table 1

Site Details

Trial number	Location	Principal weeds	Spraying date(s)	Assessment dates months after spraying (MAS)
1*	Notts.	Urtica dioica Ranunculus repens	25 Jun. '80	1 , 12
2*	Leics.	Urtica dioica Ranunculus repens Cirsium arvense	2 Jul. '80	1 , 3 , 11
3*	Derby.	Rumex obtusifolius Rumex crispus	19 Aug. '80 + 8 Jul. '81	1 , 3 , 12
4*	Staffs.	Rumex obtusifolius	15 Aug. '80 +11 Aug. '81	3 , 12
5*	Derby.	Rumex obtusifolius Urtica dioica Ranunculus repens Cirsium arvense	25 Jun. '80 8 Jul. '81	1,3, 10 , 22
6	Lincs.	Rubus fruticosus	12 Jun. '80	3 , 12
7	Notts.	Rubus fruticosus	12 Jun. '80	3 , 12
8	Derby.	Rubus fruticosus	29 Jul. '80	3 , 10
9	Notts.	Ulex europaeus Sarothamnus scoparius	11 Jul. 80	1 , 10

* Replicated small plot trial

RESULTS

Grassland Sites

Triclopyr produced growth effects typical of hormone herbicide, e.g. leaf epinasty, curling and discolouration followed in due course by death. Excellent and rapid control of U. dioica was given by all treatments one month after application (Table 2). This was maintained for 12 months. Triclopyr gave marginally, but not significantly, better long-term control than 2,4,5-T in trial 5.

Table 2

Control of U. dioica, 1 and 10 or 12 months after application of triclopyr in June or July 1980

		Trial Number 1		2		5	
		Assessment (months after spraying)					
		1	12	1	12	1	10
Chemical	g a.i./ha	EWRC scale				Control, %	
Trichlopyr	960	1.0	2.0	1.0	2.3	96	90
	1440	1.0	2.0	1.0	2.3	98	95
	1920	1.0	2.0	1.0	2.0	98	92
2,4,5-T	2100	1.0	2.0	1.0	2.0	98	85

There was rapid initial control of Rumex spp. following a mid summer application of triclopyr (Table 3). Three months after this application over 76% control was apparent and while there was a suggestion of a dose response this was not significant. Between 10 and 12 months after spraying control of Rumex spp. had declined to as low as 63% but again there was no significant difference between rates. Over the first year, triclopyr gave comparable control to asulam but was significantly superior to 2,4,5-T.

Table 3

Percentage control of Rumex spp. during the first 12 months after application of triclopyr in June or August 1980

		Trial Number					
		3		4		5	
		Assessment (months after spraying)					
Chemical	g a.i./ha	1	12	3	12	3	10
Triclopyr	960	97 b*	76 b	76 b	69 b	90 a	85 a
	1440	99 b	83 b	83 bc	63 b	94 a	84 a
	1920	98 b	87 b	92 c	75 b	96 a	89 a
Asulam	1120	98 b	78 b	86 bc	73 b	-	-
2,4,5-T	2100	-	-		-	28 b	36 b
Untreated (plants/plot)	-	(28)a	(91)a	(57)a	(32)a	-	-

* In this and all subsequent tables figures in vertical columns with the same letter are not significant different at P = 0.05.

At 12 months a further application of triclopyr gave good initial control of regrowth. Ten months after this spray, there was a dose response to triclopyr which was significant in two trials and it was also evident that a two-spray programme of 1440 g a.i./ha and above was sometimes significantly better than a comparable programme of asulam (Table 4).

Table 4

Percentage control of Rumex spp. in May/June 1982, 10 months after the completion of a two-spray programme of triclopyr made in June/August 1980 and July/August 1981

		Trial		
		3	4	5
Chemical	g a.i./ha per spray		Control, %	
Triclopyr	960	74 bc	48 bc	81 c
	1440	77 bc	72 cd	90 b
	1920	82 c	85 d	100 a
Asulam*	1120	62 b	31 ab	91 b
Untreated (plants/plot)	-	(41)a	(25)a	-

* Asulam followed asulam in trials 3 and 4 but followed a first spray of 2,4,5-T in Trial 5.

Results from trial 3 show that triclopyr gave similar control of both *R. obtusifolius* and *R. crispus* (Table 5).

Table 5

Percentage control of R. obtusifolius and R. crispus following sprays of triclopyr made in August 1980 and July 1981

		R. obtusifolius		R. crispus	
		Assessment Time			
Chemical	g a.i./ha	Nov. '80	Jun. '82	Nov. '80	Jun. '82
Triclopyr	960	82 b	74 b	88 b	72 bc
	1440	93 b	81 b	94 b	74 bc
	1920	93 b	85 b	85 b	84 bc
Asulam	1120	97 b	65 b	94 b	63 b
Untreated (plants/plot)	-	(55)a	(22)a	(16)a	(17)a

Other Weeds

Ranunculus repens occurred in three trials and weed control was variable particularly at the lowest rate of triclopyr (Table 6).

Table 6

Control of R. repens, 1 and 12 months after application of triclopyr

		Trial Number					
		1		2		5	
		Assessment (months after spraying)					
		1	12	1	12	1	12
Chemical	g a.i./ha	EWRC scale				Control, %	
Triclopyr	960	7.7	8.7	7.8	5.0	72 c	74 b
	1440	8.0	7.5	8.0	4.0	80 b	81 ab
	1960	7.7	8.0	8.0	2.0	82 b	90 a
2,4,5-T	2100	7.7	7.5	9.0	4.3	95 a	86 a
		NS	NS	NS	NS		

In two trials (2 and 4) with low populations of *C. arvense*, rates of triclopyr between 960 and 1960 g ai/ha gave some suppression 12 months after spraying (2.0 to 2.7 on EWRC scale).

Hedgerow/Railway sites

The effect of triclopyr on *R. fruticosus*, *U. europaeus* and *S. scoparius* was excellent at all rates (Table 7) in four non-replicated trials.

Table 7

Control of *R. fruticosus*, *U. europaeus* and *S. scoparius*, 12 months after treatment with triclopyr

		R. fruticosus			*U. europaeus*	*S. scoparius*
		Trial			Trial	Trial
		6	7	8	9	9
Chemical	g a.i./ha	EWRC scale			Control, %	
Triclopyr	960	1.0	1.0	100	100	100
	1440	1.0	1.0	100	100	100
	1920	1.0	1.0	100	100	100
2,4,5-T	2100	1.0	1.0	100	100	100

DISCUSSION

These trials have shown that triclopyr at 960 g a.i./ha gives rapid and excellent control of *U. dioica* which is equal or better than the currently 'Approved' standard, 2,4,5-T.

After a repeat application, triclopyr gave significantly better control of *Rumex spp.* than the standard asulam but at the lowest rate this was barely adequate. It is suggested that for effective control two annual sprays of triclopyr at 1440 g a.i./ha should be used. Equally effective control of both *R. obtusifolius* and *R. crispus* was given by triclopyr.

It is apparent that at these rates the use of triclopyr will also give useful control of *R. repens* and possibly *C. arvense*.

The programme confirmed the work reported previously by Gilchrist (1980) and McCavish (1980) that triclopyr at 960 g a.i./ha will control *R. fruiticosus*, *U. europaeus* and *S. scoparius*.

Triclopyr therefore now offers the opportunity to control two major weeds of grassland (*Rumex spp.* and *U. dioica*) with a single chemical as well as providing useful control of some scrub weeds.

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REFERENCES

GILCHRIST, A.J. (1980). Control of woody weeds in Forestry with Triclopyr. Proceedings Weed Control in Forestry Conference, 249-256.

McCAVISH, W.J. (1980). Herbicides for Woody Weed Control by Foliar Application. Proceedings of the 1980 British Crop Protection Conference - Weeds, 729-737.

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EVALUATING HERBICIDES FOR SELECTIVE CONTROL OF *SENECIO JACOBAEA* IN GRASS/CLOVER SWARDS

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Summary. Autumn application of 2,4-D or MCPA for *Senecio jacobaea* (ragwort) control offers several advantages over spring application but is even more damaging to clover. When six clover-safe herbicides were compared in autumn 1979, only asulam gave better than 90% control of ragwort and none was as effective as 2,4-D or MCPA. Asulam applied in autumn 1980 gave similar results but was totally ineffective when rain fell shortly after spraying. It slightly reduced herbage yield when applied in the year of establishment of the grass, but 2,4-D ester was much more damaging, the yield reduction being far greater than could be accounted for by the loss of clover. Delaying asulam or 2,4-D application until late autumn reduced the damage caused to both clover and total herbage yield. Asulam, 2,4-D, herbage yield, ragwort.

INTRODUCTION

Ragwort (*Senecio jacobaea* L.) and marsh ragwort (*S. aquaticus* Huds.), both poisonous grassland weeds distributed widely in the British Isles, are particularly prevalent in swards receiving low inputs of nitrogen fertiliser (< 100 kg N/ha/a). In such swards legumes, mainly white clover (*Trifolium repens*), are very important, contributing up to 25% or more of digestible dry-matter yield. A major disadvantage of herbicides currently recommended for ragwort control is that they severely damage clover, though 2,4-D and MCPA are less devastating and prolonged in their effect than herbicides containing dicamba and/or mecoprop.

The clover-safe herbicide asulam gave inadequate control of *S. aquaticus* in trials in Orkney when compared with 2,4-D ester and MCPA (Forbes, 1977). However, autumn application of 2,4-D, MCPA or herbicides containing dicamba and/or mecoprop proved to be an effective alternative to spring spraying for ragwort control (Courtney and Johnston, 1976; Forbes, 1978). It therefore became desirable to re-examine asulam and other clover-safe materials as potential ragwort control agents for use in autumn.

Although autumn spraying can give only one year's freedom from flowering ragwort, not two as is possible with spring spraying (Forbes, 1978), it quickly found commercial favour. It interferes much less than spring treatment with grazing management, which has to take account of the need to keep livestock out of sprayed areas for at least three weeks because of increased palatability of ragwort. It also allows sufficient time for the weed to die, ensuring a ragwort-free silage or hay crop in the following season. However, when autumn spraying on farms was monitored in 1978-79, clover damage from both 2,4-D and MCPA was apparent as a major problem, being even more severe than was normally observed following spring spraying.

A trial (Experiment 1) was therefore set up to test a range of clover-safe herbicides, applied in autumn, for control of *S. jacobaea*. A subsequent trial (Experiment 2) investigated the effects of dose rate and date of application of the most successful of these, namely asulam, on *S. jacobaea* control, clover and herbage yield.

METHODS AND MATERIALS

Experiment 1

The site chosen was a barley stubble field undersown with perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) and heavily infested with *S. jacobaea*, on light sandy soil at Lossiemouth, Moray. Herbicides were applied to 6 m x 20 m plots, replicated twice, in mild, calm, dry weather on 2 November 1979 using a knapsack sprayer fitted with a wide-angle fan nozzle and delivering about 225 litre/ha. Herbicide treatments were as listed in Table 1; 2,4-D ester and MCPA were included as standard treatments. Eight plots were left unsprayed. The experiment was fully randomised.

All *S. jacobaea* plants in each plot were counted immediately before spraying and flowering stems were counted on 7 July 1980. Pre-treatment counts in unsprayed plots ranged from 28 to 211. Post-treatment counts (y) in these plots were related to pre-treatment counts (x) by the linear regression equation $y = 1.165x + 20.1$ ($r = 0.963$). The "expected" value for each treated plot was calculated from this equation; for statistical analysis a logarithmic transformation of the ratio of actual to "expected" value was used. Per cent control of ragwort was obtained by subtracting this ratio from 1 and multiplying by 100.

Clover ground cover was estimated on a 0-9 scale before spraying and again on 25 April and 7 July 1980. A crude estimate of clover mortality was calculated from these data by a procedure similar to that for ragwort control. A 1 m x 20 m strip in the middle of each plot was cut on 7 July 1980 for herbage yield measurement, a sample of herbage from each plot being taken for determination of dry-matter content.

Experiment 2

Herbicides were applied in autumn 1980 to 6 m x 20 m plots in a randomised block experiment with three blocks at each of three sites, one of which had to be discarded later because of tractor damage. Of the remaining two sites one was an old perennial ryegrass-based pasture at Aberdeen, rich in white clover and heavily infested with *S. jacobaea*. The other, at Lossiemouth, was a barley stubble undersown with perennial ryegrass and white clover, similar to that used for Experiment 1 but more uniform and with very little ragwort. Spraying was carried out on two dates at each site, using the same equipment as in Experiment 1. Rain fell shortly after spraying on the later date at Aberdeen but otherwise weather conditions were excellent. Treatment details are given in Tables 2 and 3; 2,4-D ester was included as a standard treatment. Two plots in each block were left unsprayed.

At Aberdeen, all ragwort plants in each plot were counted immediately before spraying and flowering stems were counted on 30 June 1981. Pre-treatment counts in unsprayed plots were much less variable than in Experiment 1 and the regression procedure described above was not appropriate for calculation of per cent control. Instead this was calculated by the method of Forbes (1974). A logarithmic transformation of the ratio of post-treatment to pre-treatment count for each plot was used for statistical analysis. Clover ground cover was assessed on a 0-9 scale before spraying and again on 30 June 1981, and clover mortality was estimated as for Experiment 1.

At Lossiemouth the plots were so uniform that a pre-treatment clover assessment was unnecessary. On 1 July 1981 a central 1 m x 20 m strip was cut in each plot. The herbage was weighed fresh and a sample was taken for separation into grass and clover and for determination of dry-matter content.

RESULTS

Experiment 1

Per cent ragwort control and clover mortality are shown in Table 1. None of the clover-safe materials gave as good control of ragwort as 2,4-D ester or MCPA, asulam being the only one to give better than 90% control. Both 2,4-D ester and MCPA seriously damaged clover but by July 1980 the clover had substantially recovered from 2,4-D ester, though not from MCPA.

Table 1

Ragwort control and clover mortality following herbicide application on 2 November 1979

Herbicide	Rate (kg/ha)	Ragwort control (%) July 1980	Clover mortality (%) April 1980	Clover mortality (%) July 1980
Asulam	1.1 a.i.	92 bc	14 a	11 abc
	2.3 a.i.	96 c	20 a	18 abc
Benazolin + 2,4-DB + MCPA	7 litre/ha[1]	72 a	-4 a	2 a
2,4-DB	2.3 a.e.	76 a	20 a	15 abc
	4.5 a.e.	73 a	22 a	10 abc
2,4-DB + MCPA	2.3 a.e.[2]	79 a	19 a	7 ab
MCPB	2.3 a.e.	82 ab	13 a	2 a
	4.5 a.e.	82 ab	-1 a	5 ab
MCPB + MCPA	2.3 a.e.[3]	77 a	20 a	22 bc
2,4-D ester	1.7 a.e.	100 d	82 b	26 c
MCPA	2.3 a.e.	99 d	69 b	72 d

Means within each column followed by the same letter do not differ signficantly (P = 0.05).

[1] of product 'Ley-Cornox'.

[2] total acids; product 'Embutox Plus'.

[3] total acids; product 'Tropotox Plus'.

Herbage dry-matter yields in this experiment averaged 0.98 t/ha, a typically poor hay crop for this very drought-prone site. Individual plot yields were so variable that no useful conclusions could be drawn on the effect of herbicides. There was a suggestion of reduced yield with the high rate of asulam.

Experiment 2

Table 2 shows per cent ragwort control and clover mortality following early and late autumn application of asulam and 2,4-D ester at Aberdeen. Results of the early treatment were similar to those obtained in Experiment 1. The total failure of late-applied asulam to control ragwort probably results from rain shortly after spraying rather than the lateness *per se*. The oil-in-water emulsion formulation of 2,4-D ester is considerably more rain-fast; this property was well demonstrated by Forbes *et al*. (1980).

Table 2

Ragwort control and clover mortality (assessed 30 June 1981) following herbicide application in autumn 1980 at Aberdeen

Date of application	Herbicide	Rate (kg/ha)	Ragwort control (%)	Clover mortality (%)
10 October	asulam	1.1 a.i.	89 bc	2 b
		1.7 a.i.	94 cd	3 b
		2.3 a.i.	96 de	-5 b
	2,4-D ester	1.7 a.e.	97 e	31 c
21 November	asulam	1.1 a.i.	10 a	3 b
		1.7 a.i.	-13 a	-11 ab
		2.3 a.i.	6 a	-28 a
	2,4-D ester	1.7 a.e.	82 b	-2 b

Means within each column followed by the same letter do not differ significantly (P = 0.05).

Table 3 shows total herbage and clover dry-matter yield at a hay cut following early and late autumn application of asulam and 2,4-D ester at Lossiemouth. In this experiment clover was devastated by early application of 2,4-D ester and had made little recovery by July 1981. Late application, when there was less clover leaf area to accept the spray, did considerably less damage. Asulam was more damaging to total herbage yield when applied early than when applied late; not surprisingly the damage increased with dose rate. What was unexpected was the severe damage to total yield caused by 2,4-D ester. This was far greater than could be accounted for by the loss of clover.

Table 3

Effect of herbicide application in autumn 1980 on total herbage and clover dry matter yield on 1 July 1981 at Lossiemouth

Date of application	Herbicide	Rate (kg/ha)	Dry matter yield (kg/ha) Total herbage	Clover
30 September	asulam	1.1 a.i.	1927 bc	460 b
		1.7 a.i.	1893 cd	347 d
		2.3 a.i.	1740 d	315 d
	2,4-D ester	1.7 a.e.	1300 f	45 f
4 November	asulam	1.1 a.i.	2210 a	522 a
		1.7 a.i.	2073 ab	457 b
		2.3 a.i.	1883 cd	392 c
	2,4-D ester	1.7 a.e.	1507 e	236 e
Untreated			2187 a	545 a

Means within each column followed by the same letter do not differ significantly (P = 0.05).

DISCUSSION

The results presented here suggest that asulam, perhaps at a rate of 1.7 kg a.i./ha, is worth considering as an alternative to 2,4-D or MCPA for autumn spraying of ragwort in situations where clover is important. It can be expected to give over 90% control of ragwort without serious damage to clover. This degree of control is not, however, quite as good as can be achieved with 2,4-D ester. Another weakness of asulam is its dependence on dry weather following spraying, a factor which is often critical for the success of autumn treatment of ragwort. Furthermore, where the sward is rich in asulam-sensitive grasses such as *Holcus* spp., *Agrostis* spp. and *Poa* spp. some reduction in herbage yield can be expected.

This last problem is not, however, restricted to asulam. Results presented here, and by Courtney and Johnson (1980), suggest that 2,4-D and related herbicides may also be damaging to grass under some conditions. The severe yield loss caused by 2,4-D ester in this study occurred in first-year grass under considerable drought stress and is unlikely to occur in older grass where ragwort is more commonly a problem. A recent trial, not yet published, has verified that 2,4-D ester, applied in November 1981 to third-year grass containing no clover, caused no depression in silage yield in June 1982.

The use of clover-safe herbicides is not the only approach to improving the selectivity of ragwort control in grass/clover swards. This study has shown that it may be possible to minimise clover damage from 2,4-D or MCPA by delaying application until late autumn, by which time most of the clover has died back and has little leaf area to absorb the herbicide. More work is needed to elucidate the factors influencing the degree of clover damage caused by grassland herbicides not normally considered to be clover-safe.

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REFERENCES

Courtney, A. D. and Johnson, R. M. (1980). The effect of herbicides on the dry matter yield and regrowth elongation of an established *Lolium perenne* (ryegrass) sward. Proceedings 1980 British Crop Protection Conference - Weeds, 2, 589-599.

Courtney, A. D. and Johnston, R. (1976). An extended season of herbicides application for the control of *Senecio jacobaea*. Proceedings 1976 British Crop Protection Conference - Weeds, 2, 611-618.

Forbes, J. C. (1974). Spraying and cutting experiments on ragwort (*Senecio jacobaea* L. and *S. aquaticus* Hill). Proceedings 12th British Weed Control Conference, 2, 743-750.

Forbes, J. C. (1977). Chemical control of marsh ragwort (*Senecio aquaticus* Huds.) in established grassland. Weed Research, 17, 247-250.

Forbes, J. C. (1978). Control of *Senecio jacobaea* L. (ragwort) by autumn or spring herbicide application. Weed Research, 18, 109-110.

Forbes, J. C., Kilgour, D. W. and Carnegie, H. M. (1980). Some causes of poor control of *Senecio jacobaea* L. by herbicides. Proceedings 1980 British Crop Protection Conference - Weeds, 2, 461-468.

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EXPERIENCES IN CONTROLLING BROMUS MOLLIS L. IN PERMANENT SWARDS

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Summary. The incidence of soft brome infestation has increased in recent years particularly in upland hay meadows. A series of trials was initiated to evaluate various herbicides for the selective removal of this weed grass whilst causing the minimum damage to the preferred species within the sward. Phase 1 involved the initial screening of a range of herbicides, from which ethofumesate, TCA and TCA/dalapon were taken to phase 2. This involved evaluating these materials over a wider range of rates and timings. Phase 3 was carried out on large 0.1 ha plots where short-term effects on soft brome infestations were noted as well as population changes over a period of years. The programme has now progressed to farm trials of a tank mix of 2.8 kg TCA + 0.5 kg dalapon. Soft brome, Bromus mollis, hay meadows, herbicide, weed grass.

INTRODUCTION

Soft brome (Bromus mollis L) is the most widespread of all British species of brome (Hubbard, 1954), occurring frequently on roadsides waste ground, in meadows, hay fields and on cultivated land in all parts of the British Isles but most commonly in the lowlands. A marked increase in the B. mollis content of established grassland in southern Scotland was noted by Copeman (1978) and in the west of Scotland (Harkess, 1977), whilst in northern England, reports were received by the Agricultural Development and Advisory Service (ADAS) that B. mollis infestations were increasing in upland hay meadows.

The problem appeared to be worst on mainly sheep farms where meadows are used for lambing, followed by cutting a late mature hay crop, with B. mollis seed shed in the swath during haymaking maintaining the infestation. The inflexible systems of farming practised in the uplands prevent changes in management which would eliminate B. mollis seed production. Therefore the selective removal of this weed grass with a herbicide is regarded as an important approach in developing a system of control which commercial farmers could adopt.

METHODS AND MATERIALS

Experimental sites were located at Woodland, Co Durham (in 1978/79), Blanchland, Co Durham (1978/79), Blanchland (1979/80) and Redesdale Experimental Husbandry Farm, Northumberland (1980/81).

The sites were all on moderately well drained soils on farms where the ingress of B. mollis was causing concern. The trial area was fenced at Woodland but the remaining experimental areas are subject to normal farm management. Plot size was 4 x 10 m on the first 3 sites with treatments being applied by 2 passes per plot of a propane powered sprayer with a 2 m Oxford precision sprayer boom using 00 jets. For the large (0.1 ha) plots at Redesdale, a Dorman sprayer was used with a 5.4 m boom and fan-type nozzles. All treatments were applied in 225 l of water at 2 bars, except for linuron, which was applied in 400 l.

The materials used in this investigation were: 20% ethofumesate (as product Nortron); 70% methabenzthiazuron (Tribunil); 50% linuron (Linuron 50); 74% TCA + dalapon (Teedal); 95% TCA (Tecane); 85% dalapon (PP dalapon); asulam + CMPP + MCPA (Graslam). Dates of spraying were related to the known periods of activity of the herbicides under trial. After spraying, grazing livestock were excluded for 7 days.

Numbers of B. mollis flowerheads per 10 quadrats of 50 x 50 cm per plot were recorded during late June. Harvesting was carried out immediately before the farmer commenced cutting the hay crop. A central swath, 0.9 x 6 m, was cut using an auto-scythe leaving a 5 to 7 cm stubble. Herbage was weighed, sampled for dry matter, MAD fibre content and assessed for in-vitro digestibility.

RESULTS

The most noticeable phytotoxic effects occurred on the dalapon and dalapon + TCA treated swards. On a visual inspection, the late autumn treatment produced the most severe effects. Plots of these treatments were later invaded by broad-leaved weeds. Methabenzthiazuron, the asulam mixture and ethofumesate caused phytotoxic effects selectively to B. mollis and cocksfoot (Dactylis glomerata).

Following the autumn sprayings, all plots were grazed with sheep. Plots treated with methabenzthiazuron were less grazed than all other plots and suffered more from winter kill.

During the winter months, the autumn-treated plots tillered well and produced uniformly dense swards by the spring. There was not, however, sufficient interval between the application of the spring treatments and the harvest for grasses to fill in the gaps. Consequently, spring-applied herbicides produced uneven swards.

Table 1

Effect of various herbicides on density of B. mollis seedheads at Woodland, 1979

Herbicide	Rate/ha	Application date	Heads X1,000/ha	Seedhead control (%)
Ethofumesate	10 l/ha	20 November	21	95
Dalapon	2 kg/ha	20 November	67	86
Asulam + CMPP + MCPA	8.5 l	19 September	371	20
Methabenzthiazuron	4.5 kg	19 September	105	77
TCA + dalapon	9 kg	13 October	0	100
Linuron	3 kg	20 November	328	30
Untreated control			466	0
		SE means	± 130	

Table 1 shows that the highest degree of control was achieved by the TCA + dalapon treatment (100%) closely followed by the ethofumesate (95%). The linuron and asulam mixture gave very poor control at all dates of application.

Three of the most promising treatments (see table 2) were carried forward to 1979/80 in order to examine them over a wider range of rates and timings. Weather conditions in October 1979 were ideal for spraying. However, the November applications were followed by heavy rain within half an hour. This produced two features: firstly, the irregular performance of ethofumesate treated plots and secondly, a very much reduced herbicidal action from the dalapon (table 2). TCA +

dalapon performed well despite the rain, giving results comparable with those from the October application.

1979/80

Table 2

Effect of various herbicides applied at 2 dates on % control of *B. mollis* flowerheads and total DM (t/ha) 1980

Herbicide	Rate/ha	Month of Application October	Month of Application November	Month of Application October	Month of Application November
		% Control	% Control	Yield t/ha	Yield t/ha
ethofumesate	10 l	95	71	6.57	6.06
ethofumesate	7 l	80	87	5.81	6.36
dalapon	1.0 kg	60	Nil	5.75	5.57
dalapon	1.5 kg	73	10	4.75	5.12
dalapon	2.0 kg	86	22	4.58	5.36
TCA/dalapon	3 kg	73	74	5.14	5.34
TCA/dalapon	5 kg	94	99	4.75	4.37
TCA dalapon	7.0 kg	97	98	4.20	3.44
Untreated control				5.50	

Mean seedhead count on untreated plots = $92/m^2$

SED means = $\pm$ 20.06

SE per plot $\pm$ 0.44 t/ha;
SED = $\pm$ 0.36 t/ha;
C of V = 8.42%

In spring 1980 autumn-treated plots were invaded by broad-leaved weeds where *B. mollis*, *Poa trivialis* and *Alopecurus pratensis* had been removed from the sward. As in the previous years trial, TCA + dalapon was the most effective material tested for reducing a *B. mollis* infestation. It also had the effect of "opening up" the sward at the higher rates employed and significantly reduced hay yield (table 2).

The most uniform plots in the trial were those treated with ethofumesate. These treatments produced herbage dry-matter yields in excess of those of the controls. However, clover had been completely eliminated from the sward.

For 1980/81, it was decided to proceed to larger scale unreplicated plots so that *B. mollis* population trends could be monitored following the application of herbicidal treatments. Since it was learned that the TCA + dalapon formulated product was not likely to be marketed in the UK it was proposed to use tank mixes of TCA and dalapon in future work. The rates of active ingredient to be used in this work could not be worked out arithmetically from those used previously with the formulated product.

A trial carried out previously showed that 9 kg TCA + dalapon reduced the yield of herbage dry matter by 17% more than the same amount of ai in a TCA dalapon tank mix (in a *B. mollis* free situation). For this reason the rates of ai in this trial were increased by 20% to give treatments approximating to 3, 4 and 5 kg TCA + dalapon formulated product.

The results (table 3) showed that all the autumn-applied treatments gave a high degree of control whilst those applied in spring were variable in effect.

Table 3

B. mollis % control, Redesdale 1981

Herbicide and rate	Autumn (10 Oct) application %	Spring (9 April) application %
ethofumesate 10 l	100	38.2
TCA 2.4 kg + 0.47 kg dalapon	95.4	61.9
TCA 3.2 kg + 0.62 kg dalapon	97.5	13.8
TCA 4.0 kg + 0.78 kg dalapon	99.4	73.3
Untreated control	Nil	Nil

Mean seedheads on untreated controls = $560/m^2$

DISCUSSION

The similarity between *B. mollis* as a weed of hay meadows and wild oat (*Avena fatua*) as a weed of cereals becomes immediately apparent. Both are extremely effective competitors within their host crop. Moreover, Chancellor (1978) found in pot trials involving grass species, *B. mollis* was second only to *Anisantha sterilis* in terms of growth and development during the 3 months after sowing. Both compete for light and space by growing above the host crop. They also generate hugh quantities of seed which can quickly produce high populations of plants.

Control of *B. mollis* can best be achieved by preventing seed returning to the ground, as in the case of *A. fatua*. A change in management system to prevent seed return is an option open to the lowland grassland farmer, eg, a change of conservation system from hay to silage, or a full year of grazing and topping every other year. However, upland systems of farming are often too inflexible to allow this kind of change to be made. Selective removal with a herbicide is therefore an important approach in controlling this weed.

Timing the herbicide application requires a knowledge of when *B. mollis* seed germinates and hence when plants will be at a susceptible stage. As *B. mollis* displays a lack of dormancy (R. J. Chancellor, personal communication), germination may be expected shortly after seed is shed, ie, late summer. However, Goldsworthy and Drummond (1981) and Harkess and Frame (1981) also report a significant spring germination in Scotland. Clearly, an autumn application of herbicide would only control weeds present at the time and it was essential therefore to ascertain whether the Scottish situation prevails in north east England. To this end the author carried out a trial during 1979. Turves were taken from a field severely infested with *B. mollis* and desiccated with glyphosate during February/March. In late May, *B. mollis* seedheads were noted, but these originated from plants growing only on the vertical side of the turves. It would appear, therefore, that the seed must have become buried at shedding time - either by poaching or more likely by shedding onto cracked soil; the constant temperature and lack of sunlight would then induce a state of dormancy (Chancellor, 1979). Breaking dormancy would probably result from soil disturbance, eg, early spring poaching of hay meadows.

With the proviso, therefore, that hay meadows are lightly stocked, it would appear that an autumn application of herbicide would coincide with *B. mollis* being present as seedlings and would achieve a high degree of control. A spring application, however, would find the plants in a well tillered state; the control achieved in practice has been variable at this time.

The TCA + dalapon mixture appears to sensitise all grasses to frost. To minimise this effect, it is necessary to apply the treatment before severe frosts are expected. At present, September/early October timings appear to result in least visual damage to the preferred species.

The true cost of eliminating B. mollis by herbicide is not easy to deduce, since there will be many side issues to consider. In the case of ethofumesate treatment, the herbicide and application costs are obvious, but the long-term consequence of losing clover from the sward is difficult to ascertain. TCA/dalapon will not eliminate clover but, since it will depress herbage dry-matter yield by about 10% in the treatment year, this loss must be added to the cost.

The implications of dormancy and rate of population increase in B. mollis have still to be assessed. Since these aspects will affect the frequency of re-treatment, and hence the total cost of the programme, they are currently under study in a long-term project in north east England involving several farmers who have been provided with sufficient TCA/dalapon to treat 1 ha of an infested field. These sites will be monitored over an extended period to determine the effectiveness of the control.

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REFERENCES

Chancellor, R. J. (1979). Grass seeds beneath pastures. British Grassland Society, Occasional Symposium, (10), 147-150.

Copeman, G. (1978). Scotland's green revolution - what next? "New ways to maximise grassland production". Fison's Ltd occasional conference, Glasgow.

Goldsworth, J. A.; Drummond, D. J. (1981). Control of soft brome (Bromus mollis) in established grassland of Scotland with ethofumesate. Proceedings, Crop Protection in Northern Britain 1981, 225-230.

Harkess, R. D. (1977). Soft brome, West of Scotland College Agronomy note 77/15, 3pp.

Harkess, R. D.; Frame, J. (1981). Weed grasses in sown grassland with special reference to soft brome (Bromus mollis L). Proceedings, Crop Protection in Northern Britain 1981, 231-236.

Hubbard, C. E. (1954). Grasses: Penguin Books Ltd, London.

TWO SURVEYS OF THE POTENTIAL USE OF A TECHNIQUE FOR CONTROLLING TALL WEEDS IN GRASSLAND

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Summary. Of 828 grass fields observed from the roadside during mid-July to late August 1980, 32% contained weeds which were visibly taller than the grass over the whole field, and a further 12% contained tall weeds over part of the field. The most frequent weeds were thistles (*Cirsium* spp.), 60% of weedy fields, docks (*Rumex* spp.), 18%, and nettles (*Urtica* spp.), 16% of weedy fields. In an observation of six individual fields a height differential of up to 15 cm was recorded from July to October 1980 between *Rumex obtusifolius* and grazed grass but only 3 cm in grass cut for hay or silage. It is suggested that up to 1 m ha of grazed grass in England and Wales could be treated using the technique of selective application of herbicides to control tall weeds by exploiting these height differentials. Selective application, docks, thistles, nettles, silage, grazing.

INTRODUCTION

The technique of selective application of herbicides to control tall weeds in grassland depends upon there being an adequate height difference between weed and crop otherwise damage occurs due to contact with the applicator and contamination from treated herbage (Oswald, 1980). Peel and Hopkins (1980) showed thatdocks (Rumex spp.), although less widespread than thistles (Cirsium spp.) in terms of area covered, usually inhabit the more productive grassland. The same workers indicated the extent of the problem in grazed grass, while the relationship with grass conserved for silage was shown by Haggar (1980).

In the first of two surveys, the potential area for applying the selective application technique was established by recording the incidence of fields with height differences between tall weeds and grass. The survey was carried out by Weed Research Organization (WRO) staff travelling to off-station experiments during July and August 1980. A second survey, aimed at identifying the optimum period for use of the technique; it was undertaken from May to October 1980 and concentrated on measuring height differences between *R. obtusifolius* and grass in grazed and hay or silage conservation situations.

METHOD AND MATERIALS

Survey 1. Potential for selective application

A total of 828 grass fields were observed during the period 17 July to 27 August 1980. The grassland involved ranged from Oxfordshire through Northants, Warwickshire, Staffordshire and into Cheshire in the north, to Berkshire, Hampshire and Wiltshire in the south and west. Simple forms were provided for completion by WRO passengers en route to experimental sites. A specific start point was identified on each journey and as many grass fields as possible were assessed in succession up to a chosen finish point. In all cases the left hand side of the road was recorded in both directions on each journey.

Observers recorded height differentials using the following categories:

(1) = weeds visible above the grass over the whole field
(2) = some weeds visible above the grass
(3) = no weeds visible

Abbreviations were used to identify the specific weeds encountered.

Survey 2. Seasonal height difference, *R. obtusifolius*/grass

Six fields were chosen with contrasting managements. Three fields had been grazed exclusively since establishment, two were cut for silage and one was cut for hay. Even, rectangular fields were chosen so that each field length could be divided to give 10 equidistant points. Using these 10 points on two adjacent sides, each field was divided into 100 assessment positions. The height of the grass was measured at each point.The nearest *R. obtusifolius* plant to each point was also measured for height and diameter on the dates indicated in Fig. 1. The number of leaves and flower heads per plant were also recorded.

RESULTS

Survey 1. Potential for selective technique

Of the 828 fields observed, 266 (32%) were in category 1, having weed-grass height differential over the whole field (Table 1). Another 100 (12%) fields had some weeds visible above the grass canopy. In the remaining 462 (56%) fields there were no weeds visible above the grass.

Table 1

The number of fields with weeds visible above the grass, divided into 2 categories, out of 828 fields observed

	Category (1) Overall	(2) Partial	Total
Thistle	148	43	191
Dock	24	23	47
Nettle	22	12	34
Thistle/Nettle	30	4	34
Dock	23	6	29
Tufted Hair-grass	5	5	10
Thistle/Tufted Hair-grass	7	1	8
Rush	2	1	3
Thistle/Rush	1	1	2
Thistle/Ragwort	0	2	2
Dock/Nettle	1	1	2
Dock/Ragwort	1	1	2
Ragwort	1	0	1
Dock/Tufted Hair-grass	1	0	1
Total	266	100	100

Thistles (mainly *Cirsium* spp.) were the most frequent single weed observed, being recorded with a height difference in 52% of fields. Docks at 13% and nettles at 9% were next most frequent. Tufted Hair-grass (*Deschampsia caespitosa*), rush

(Juncus spp.) and ragwort (Senecio jacobaea) were present as single species in only 4% of weedy fields.

In addition, thistles, docks and nettles were observed in mixed infestations, the most frequent being thistles with nettles (9%) and docks with thistles (8%).

Thus, in terms of presence the most prevalent tall weeds were thistles which were observed as single or in mixed infestations in 60% of weedy fields followed by docks (18%) and nettles (16%) (Table 2). The remaining 6% consisted of tufted Hair-grass, rush and ragwort.

Table 2

Occurrence of individual weeds, alone and in mixed infestations, in order of frequency

	Fields showing a height difference						
	Overall		Partial		Total		
	Alone	Mixed	Alone	Mixed	Alone	Mixed	Total
Thistle	148	61	43	14	191	75	266
Dock	24	26	23	8	47	34	81
Nettle	22	31	12	5	34	36	70
Tufted Hair-grass	5	8	5	1	10	9	19
Rush	2	1	1	1	3	2	5
Ragwort	1	1	0	3	1	4	5

Fig. 1

Height difference between R. obtusifolius and surrounding grass either grazed (———) or cut (– – –), from May to October 1980

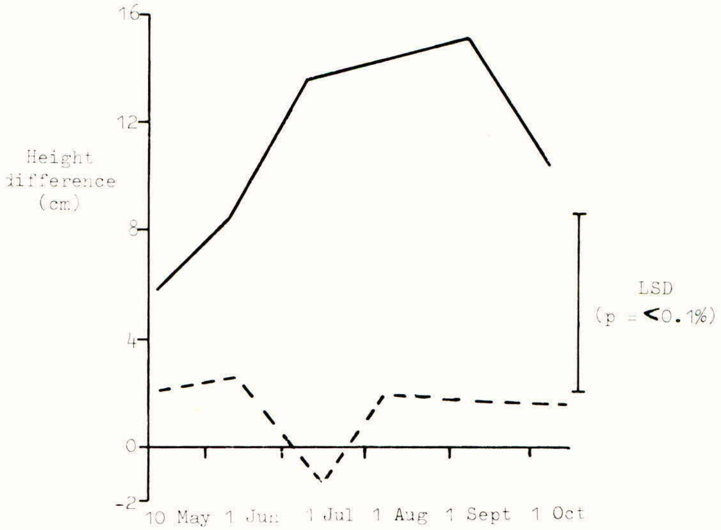


Fig. 2

Height of *R. obtusifolius* (——) and grass (– – –) from May to October 1980 in 6, variously managed fields

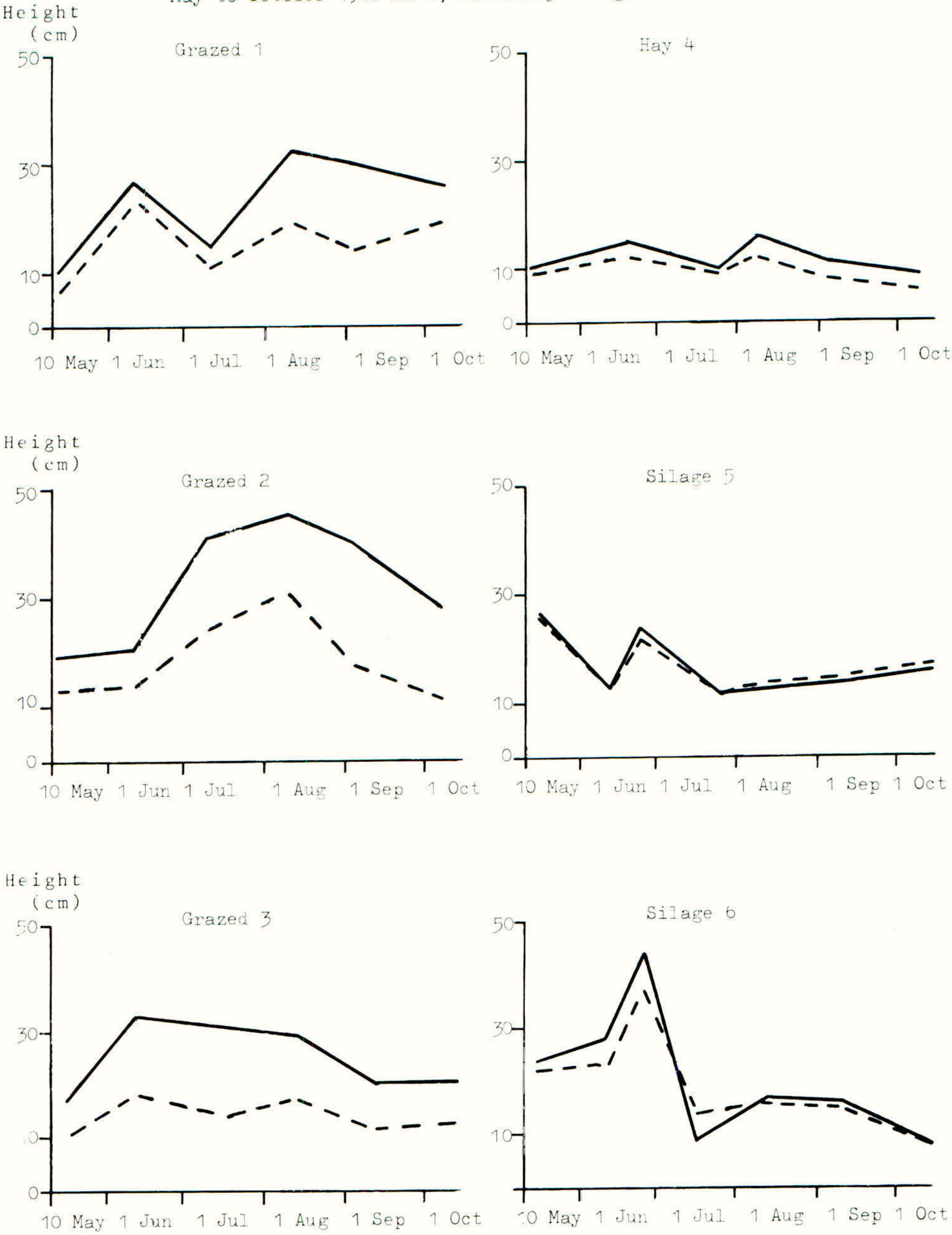
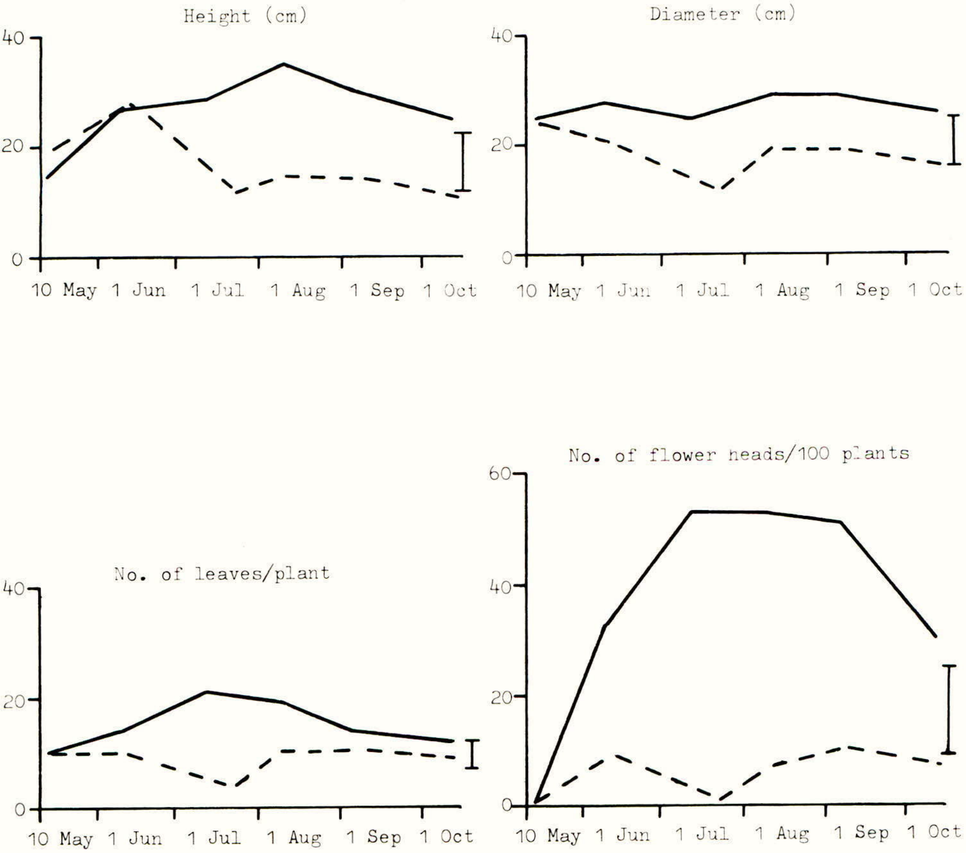


Fig. 3

Height, diameter, number of leaves and flower heads of R. obtusifolius in grass either grazed (——) or cut (- - -) from May to October 1980

= LSD (p = < 0.1%)



Survey 2. Seasonal height difference, R. obtusifolius/grass

The difference in height between R. obtusifolius and the surrounding grass was greater throughout on grazed sites than at hay or silage sites, with the difference being significant from July onwards (Fig. 1). The height difference in grazed grass ranged from 6 cm in May to 15 cm in September before falling to 11 cm by mid-October. The difference between weed and grass in hay or silage situations never exceeded 3 cm (mid-June) with the grass even being taller than the weed during mid-July.

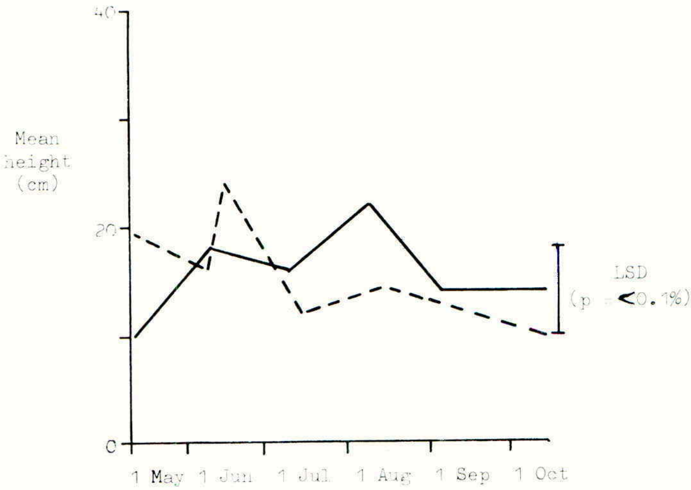
The difference in height in grazed situations was greatest during August and September at site 1, July to October at site 2 and June to August at site 3 (Fig. 2). Height of R. obtusifolius and grass at hay or silage sites was similar from May to October.

Rumex obtusifolius plants were larger in grazed grass than in grass cut for hay or silage, with the height, diameter and production of flower heads being greater, particularly from June onwards (Fig. 3). There were also significantly more leaves per plant in grazed grass than in hay or silage from late June to mid-August.

Grass height was similar in both situations although grazed grass was significantly taller during August (Fig. 4).

Fig. 4

Height of grass either grazed (——) or cut (- - -) surrounding R. obtusifolius from May to October 1980



DISCUSSION

The results of the first survey suggest that the technique of selective application of herbicides could be used as a control measure on 44% of the fields observed, where weeds were clearly visible above the grass canopy. The study also confirmed the relative importance of weeds in grassland, as indicated by the survey of Peel and Hopkins (1980), with thistles being most prevalent (60% of weedy fields), followed by docks (18%) and nettles (16%). Tufted-Hair-grass, rush and ragwort were observed in only 6% of weedy fields.

Peel and Hopkins (1980) also concluded from their survey that there were 1.5 m ha of grassland in England and Wales that are infested with thistles and docks. This present survey suggests that nearly 600,000 ha of this area could be treated using the selective technique. The addition of other tall weeds, and the inclusion of rough grazing, could mean that there is a potential area of up to 1 m which would benefit from this new method of weed control. Although docks infest a smaller area of grassland than thistles, the presence of the most common species (R. obtusifolius) in highly productive grass warrants the use of effective control techniques.

The second survey showed that there was a significant difference in height between R. obtusifolius and grazed grass from July onwards, but not with grass cut for hay or silage. The probable reason for these results is that rejection by animals allows the growth of a larger plant which achieve a greater height differential with the grass whereas both weed and grass are defoliated equally by cutting, so subsequent recovery occurs at a similar rate.

Thistles, nettles and docks in grazed pasture are obviously ideal for control by selective application techniques. However, it is questionable whether removal of thistles would lead to an economic benefit where fertility is low and grass is under-grazed.

The survey indicated that the selective technique could be used in grazing systems where a height difference of up to 15 cm between R. obtusifolius and grazed grass from mid-July to mid-September can be expected. However, a more accurate safety margin for treatment must be worked out so that grass damage from contamination is avoided.

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REFERENCES

Haggar, R.J. (1980). Survey of the incidence of docks (Rumex spp.) in grassland in ten districts in the United Kingdom in 1972. ADAS Quarterly Review, (39), 256-270.

Oswald, A.K. (1980). Progress in the development of the selective application of herbicides to control Rumex obtusifolius in grassland. Proceedings 1980 British Crop Protection Conference - Weeds, 209-215.

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

Proceedings 1982 British Crop Protection Conference - Weeds

THE EFFECT OF MEFLUIDIDE ON YIELD AND QUALITY OF 8 GRASSES

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Summary. Mefluidide, applied at 0.3 kg/ha a.i. on 3 dates in spring to field plots of 8 grasses, suppressed flowerhead production, notably in *Poa trivialis*, *Holcus lanatus* and *Arrhenatherum elatius*, especially when applied early. Vegetative yields were not significantly lowered and, since reproductive growth was retarded, quality was increased, as indicated by measurements of fibre content. The results support the concept of using a plant growth regulator to increase forage quality for improved animal productivity. Mefluidide, timing, fibre, grass yield, forage quality.

INTRODUCTION

Mefluidide is a foliar-absorbed growth regulator which suppresses seedhead formation in several grasses when applied in early spring (Bushong, Gates and Sullivan, 1976). It has proved useful for controlling vegetative and reproductive growth of turf and areas that are difficult to mow (Atkinson *et al*., 1980; Stinchcombe and Scott, 1980). For these purposes, the optimum rate for maintaining growth suppression of *Lolium perenne*, over an 8 week period, is between 0.5 and 0.75 kg/ha, although the higher rate can cause temporary phytotoxic symptoms (Field and Whitford, 1980).

The concept of using a plant growth regulator to inhibit seedhead formation, and thus maintain forage quality for animal feeding, has not been fully investigated, except in the case of *Festuca arundinacea* (Glenn *et al*., 1980; Robb *et al*., 1981, who reported a 27% increase in animal productivity using forage treated with mefluidide). Hence the current investigation was started, involving a wide range of grasses with contrasting growth habits. A single rate of mefluidide was used, viz. 0.3 kg/ha, as this was judged to give the necessary check to flowerhead production without causing prolonged growth suppression. Time of application was selected as a main variable since this was considered likely to affect the degree of suppression of seedhead production.

METHODS AND MATERIALS

Monocultures of *Agrostis tenuis*, *Agrostis stolonifera*, *Arrhenatherum elatius*, *Festuca rubra*, *Holcus lanatus*, *Lolium perenne*, *Phleum pratense* and *Poa trivialis* were established from seed sown in strips measuring 1.5 x 32.5 m by an Oyjord drill in August 1981. Each species was replicated three times, in a randomised block design. Mefluidide at 0.3 kg a.i./ha was sprayed at 300 l/ha on either 20 April, 4 May or 18 May 1982 on plots measuring 1.5 x 7 m allocated randomly within each strip of grass. One such plot was left unsprayed. The herbicide was applied in 300 l/ha at 300 kPa using a modified Oxford Precision Sprayer. Weather conditions at all three spraying times were fine and dry.

The whole area was sprayed for broad-leaved weed control two weeks before the mefluidide was applied. Four days prior to the first mefluidide application, all plots were trimmed to about 5 cm. Fertilizer nitrogen was applied at 50 and 70 kg N/ha on 25 May and 16 July respectively. Because of dry weather, all plots were irrigated with up to 2 cm of water in mid-June and early August.

On 29 June, sward height was measured using a modified sward stick (E.J.P. Marshall, personal communication). On the same date, seedhead counts were taken by recording the number of seedheads in a 30 x 30 cm^2 quadrat thrown at random on each plot. On 5 July each plot was cut at 5 cm, the herbage weighed and sampled for dry weight determination. The sample was then ground and analysed for fibre content, using a modified acid detergent technique (T.H. Byast, personal communication). A second sample was separated into vegetative and reproductive components, dried and weighed. Twenty seedheads were selected at random from each sample and the length of each inflorescence was recorded. On 12 August each plot was again harvested and sampled for total dry weight determination.

RESULTS

Mefluidide caused a marked reduction in flowerhead production (Table 1), more than halving numbers of *P. trivialis* and *H. lanatus* flowerheads. In general, the earlier the appliction the greater was the reduction, as indicated by the trend in the overall mean values. This trend was most significant in the case of *P. trivialis*. In contrast, the greatest check of *H. lanatus* flowerheads resulted from the intermediate spraying.

Mefluidide also caused a significant reduction in seedhead size (Table 1), with reductions of up to 25% being recorded in most species - notably *P. trivialis* - although these reductions were not related to spraying date. Apart from being smaller, the treated flowerheads were apparently normal except possibly for a reduced spikelet number.

Table 1

Effect of mefluidide applied on 3 dates on seedhead production (No./30x30 cm^2) and seedhead size (cm) of 8 grasses

	Seedhead number				Seedhead size			
	Application date				Application date			
Species	20 April	4 May	18 May	Unsprayed	20 April	4 May	18 May	Unsprayed
P. trivialis	10	58	77	123	5.6	4.2	6.8	7.3
H. lanatus	89	61	137	124	5.5	5.8	5.1	6.2
A. elatius	10	15	16	16	12.7	10.6	14.5	14.2
A. tenius	8	21	15	29	6.8	6.4	5.2	7.4
A. stolonifera	41	47	51	49	5.1	5.3	5.0	5.2
F. rubra	67	50	60	68	7.0	7.9	8.7	8.8
L. perenne	16	30	14	37	15.7	15.6	13.6	16.0
P. pratense	5	3	3	17	4.9	4.7	4.2	5.3
Mean	31	35	46	57	7.9	7.5	7.9	8.8
	s.e. species x date = 18.7				s.e. species x date = 0.85			

Because fewer flowerheads were present on the treated plots, such swards tended to be shorter compared with the untreated swards (Table 2), this being most noticeably significant with *P. trivialis*, *A. elatius* and *H. lanatus*.

Mefluidide did not significantly reduce the vegetative (i.e. non-flowering) component of the total DM yield of any species at any of the application dates, as indicated by a non-significant difference for date and species x date in the analysis of variance. However, mefluidide severely reduced reproductive growth (Table 3), especially when applied early, and notably to *P. trivialis*, *H. lanatus* and *A. elatius*. Hence, total yields tended to be checked by the mefluidide treatments, with a mean reduction of 30% resulting from the earliest application.

Table 2

Effect of mefluidide applied on 3 dates on sward height of 8 grasses (cm)

Species	Application date 20 April	4 May	18 May	Unsprayed
P. trivialis	8	10	13	20
H. lanatus	29	23	35	40
A. elatius	35	30	30	42
A. tenuis	8	9	9	10
A. stolonifera	7	8	9	10
F. rubra	22	25	25	28
L. perenne	16	17	15	19
P. pratense	12	11	11	16
Mean	17	17	18	23

s.e. species x date = 2.4

Table 3

Effect of mefluidide applied on 3 dates on reproductive and total yield of 8 grasses at harvest 1 (DM t/ha)

	Reproductive component				Total yield			
	Application date				Application date			
	20 April	4 May	18 May	Unsprayed	20 April	4 May	18 May	Unsprayed
P. trivialis	0.07	0.12	0.42	0.78	0.45	0.76	1.00	1.50
H. lanatus	2.18	1.13	2.89	3.53	3.68	3.46	4.96	4.69
A. elatius	0.30	0.39	0.34	1.11	2.79	2.53	3.03	3.68
A. tenuis	0.03	0.05	0.03	0.22	0.47	0.59	0.58	1.18
A. stolonifera	0.10	0.15	0.10	0.20	0.43	0.51	0.53	0.57
F. rubra	1.29	1.56	1.85	1.94	2.97	3.58	3.47	3.72
L. perenne	1.04	0.82	0.61	1.38	2.23	2.38	1.77	2.87
P. pratense	0.16	0.18	0.12	0.56	1.50	1.17	1.11	2.32
Mean	0.64	0.55	0.80	1.22	1.82	1.87	2.06	2.57
	s.e. species x date = 0.31				s.e. species x date = 0.34			

Because mefluidide reduced total bulk of DM harvested, mainly by reducing the reproductive component, the quality of the DM was thereby improved, as indicated by the significantly lower MAD fibre values on the mefluidide treatments in Table 4.

At the second harvest, regrowth from several of the mefluidide-treated plots (Table 5) was significantly greater compared with the unsprayed plots, notably with *F. rubra* and *H. lanatus*. In general, delaying spraying from 20 April to 18 May resulted in increased growth.

Combining both harvests (Table 5), it can be seen that early application of mefluidide tended to reduce total yield of most species, especially *P. trivialis*, *P. pratense* and *A. elatius*. However, spraying on 18 May resulted in yields being at least equal to the unsprayed control with several species; in the case of *H. lanatus* and *F. rubra*, yields were actually increased by 13 and 6% respectively.

Table 4

Effect of mefluidide applied on 3 dates on MAD fibre content of 8 grasses at harvest 1 (% of DM)

Species	Application date 20 April	4 May	18 May	Unsprayed
P. trivialis	25	27	30	34
H. Lanatus	35	31	33	36
A. elatius	33	32	33	33
A. tenuis	28	29	27	31
A. stolonifera	30	30	29	29
F. rubra	34	34	34	37
L. perenne	29	27	27	30
P. pratense	30	30	28	31
Mean	30	30	30	33

s.e. species x date = 1.65

Table 5

Effect of mefluidide applied on 3 dates on yield of 8 grasses at harvest 2 and harvest 1 + 2 (DM t/ha)

	Harvest 2 Application date				Harvest 1+2 Application date			
	20 April	4 May	18 May	Unsprayed	20 April	4 May	18 May	Unsprayed
P. trivialis	0.15	0.24	0.25	0.19	0.60	1.00	1.25	1.69
H. lanatus	1.11	1.15	1.06	0.60	4.79	4.61	6.02	5.29
A. elatius	0.93	0.81	0.97	1.02	3.72	3.34	4.00	4.70
A. tenuis	0.28	0.41	0.45	0.38	0.75	1.00	1.03	1.56
A. stolonifera	0.42	0.39	0.38	0.32	0.85	0.90	0.91	0.89
F. rubra	0.92	0.99	1.20	0.67	3.89	4.57	4.67	4.39
L. perenne	0.65	0.54	0.51	0.51	2.88	2.92	2.28	3.38
P. pratense	0.34	0.37	0.44	0.27	1.84	1.54	1.55	2.59
Mean	0.60	0.61	0.66	0.50	2.41	2.48	2.71	3.06
	s.e. species x date =			0.16	s.e. species x date =			0.34

DISCUSSION

This study has confirmed the effectiveness of mefluidide in suppressing the reproductive development of several grasses and increasing herbage quality without unduly affecting total dry-matter yield, thereby leading to potential increases in efficiency of livestock production.

The optimum time for applying mefluidide obviously varies with the individual species. For example, with *H. lanatus* and *F. rubra*, spraying on 18 May gave the best compromise of seedhead suppression and improved regrowth; other species, e.g. *Agrostis* spp., were less sensitive to mefluidide timing.

In other work (Jackson, Connor and Jacobson, 1980), there were indications that annual grasses were more susceptible to mefluidide than perennial grasses, and fine-leaved species were affected to a greater extent than coarse-leaved perennial grasses. However, the present results, carried out in non-turf conditions, show that species which tend to produce erect growth in early summer, notably P. trivialis, H. lanatus and A. elatius are more responsive than the finer leaved, more prostrate grasses.

Grass such as H. lanatus and P. trivialis occur commonly in undergrazed grassland (Haggar and Elliott, 1978). By running to head in early summer, they dominate other more desirable grasses and clovers, thus reducing quality in mid- and late summer and thereby reducing animal performance. Spraying mefluidide in mid-April could conceivably reduce the dominance of these species, as well as assisting the transference of some growth to later in the year. Moreover, current work (C.J. Standell, personal communication) is showing that mefluidide, by retarding grass growth at key times of the year, can be used to encourage the white clover content of mixed swards.

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REFERENCES

Atkinson, D.; Crisp, C. M.; Thomas, C.M.S. (1980) The use of plant growth regulators in the management of orchard swards: some preliminary results with mefluidide. Proceedings 1980 British Crop Protection Conference - Weeds, 693-697.

Bushong, J. W.; Gates, D. W.; Sullivan, T.P. (1976) Mefluidide (MBR 12325) - a new concept in weed control with a plant growth regulator. Proceedings 1976 British Crop Protection Conference - Weeds, 695-698.

Field, R.J.; Whitford, A.R. (1980) The effect of mefluidide on the growth of perennial ryegrass. Proceedings 33rd New Zealand Weed and Pest Control Conference, 74-78.

Glenn, S.; Rieck, C. E.; Ely, D. G.; Bush, L. P. (1980) Quality of tall fescue forage affected by mefluidide. Journal of Agriculture, Food and Chemistry, 28, 391-393.

Haggar, R. J.; Elliott, J.G. (1978) The effect of dalapon and stocking rate on the species composition and animal productivity of a sown sward. Journal of the British Grassland Society, 33, 23-33.

Jackson, I. F.; O'Connor, B.P.; Jacobson, D. J. I. (1980) Mefluidide: a plant growth regulator. Proceedings 33rd New Zealand Weed and Pest Control Conference, 67-73.

Robb, T. W.; Ely, D. G.; Rieck, C. E.; Glenn, S.; Kitchen, L.; Glenn, B. P.; Thomas, R. J. (1981) Beef production from tall fescue treated with mefluidide, a chemical growth regulator. Proceedings 14th International Grassland Congress (in press).

Stinchcombe, G. R.; Stott, K. G. (1980) Grass control in apple orchards with mefluidide. Proceedings 1980 British Crop Protection Conference - Weeds, 681-686.

Proceedings 1982 British Crop Protection Conference - Weeds

ESTABLISHMENT OF GRASS AND CLOVER DIRECT-DRILLED INTO CHEMICALLY KILLED SWARDS

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Summary. Grass seeds were direct-drilled at 7 sites and clover at 4 sites into swards desiccated by herbicide. At 3 sites glyphosate and paraquat were compared at varying intervals of 0 to 28 days before drilling. Burning the decaying sward and coating seed with calcium peroxide was also investigated. At 4 sites a more detailed investigation of the effect of various seed coatings was undertaken. Results confirm previous work that increasing interval between spraying and drilling seed increases seedling establishment. Calcium peroxide seed treatment had a variable effect on grass and clover establishment. This could be associated with rainfall and soil moisture conditions during establishment. Seed treatment with calcium carbonate and fungicide also had variable effect. Surface harrowing or discing before drilling seed improved establishment. Reseeding, calcium peroxide, spraying interval, harrowing, rotovating, paraquat, glyphosate, fungicide.

INTRODUCTION

Considerable attempts have been made recently to improve establishment of grass and clover direct-drilled into swards desiccated by herbicide. Surface trash is known to reduce establishment (Squires and Elliott, 1972) and breakdown products of previous crop residues may inhibit germination (Lynch, 1978; Habeshaw, 1980). ADAS started a series of trials in 1978 to investigate factors that affected establishment of grass and clover after sward desiccation by paraquat and glyphosate; results reported by Davies et al. (1980) indicate that increasing interval between spraying and drilling seed consistently improved seedling establishment. Burning the decaying sward improved establishment and rotoseeder drill proved better than disc drills. Coating seeds with calcium peroxide also improved establishment in two experiments (Davies and Davies, 1981). The trials reported here are a further extention of the above series.

METHOD AND MATERIALS

Three sites were established in 1980, one each in Gwynedd, Avon and Berkshire, and four in 1981, one each in Gwynedd, Dyfed, Avon and Hampshire. Brief site details are given in Table 1.

Table 1

Site Details

Sites	Sward Type	Main sward components	Soil type	Drilling date
A. Talybont, Gwynedd 1980	Long-term grass	*Holcus lanatus*, *Agrostis stolonifera*	Loam	22.8.80
B. Newton St Loe Avon	Long-term grass	*Dactylis glomerata*, *Festuca rubra*, *A.stolonifera*	Silt Loam	21.8.80
C. Shinfield, Berkshire	Long-term grass	*Lolium perenne*, *Poa annua* *P.trivialis*, *A.stolonifera*	Alluvium	22.8.80
D. Talybont, Gwynedd 1981	Long-term grass	*H.lanatus*, *A.tenuis* *A.stolonifera*	Loam	2.9.81
E. Gelli Aur, Dyfed	Long-term grass	*L.perenne*, *A.stolonifera*	Silty Loam	10.8.81
F. East Harptree, Avon	3 year ley	*L.perenne*, *L.multiflorum*	Very fine sandy loam	8.9.81
G. Basingstoke Hants	Long-term grass	*A.tenuis*, *A.stolonifera*	Silty loam	17.8.81

The following basic herbicide treatments were applied (at sites A to C): (a) Glyphosate 1.44 kg ae/ha (b) Paraquat 1.7 kg ai/ha each was sprayed either (a) 28 days before drilling (site B and C only) (b) 21 days before drilling (site A only) (c) 14 days before drilling (d) 7 days before drilling (e) 0 or 1 day before drilling (site A and C only).

Additional treatments:-

Paraquat sprayed 14 days before drilling, debris burnt	- all sites.
Glyphosate sprayed 14 days before drilling, debris burnt	) Site C only
Glyphosate sprayed 14 days before drilling, rotovated	)
Paraquat split application 14 + 7 days	)
Coating of seeds with 60% calcium peroxide concentrate applied 25% by weight	- Site A and C

All treatments were drilled on the same day. Seed mixtures used included perennial ryegrass/white clover at site A; perennial ryegrass/Italian at site B; perennial ryegrass/timothy at site C. Seed rate ranged from 28 to 34 kg/ha, with coated seed rates adjusted to sow equivalent number of seeds per unit area.

The calcium peroxide treated seed was drilled on a split-plot arrangement across main treatment plots at site A while at site C two replicates were drilled with treated seed and two with untreated seed. A Moore Unidrill was used at all sites.

Treatments in 1981 concentrated on seed (sites D to G) and cultivation (sites D, F & G) treatments.

Seed treatments were (1) calcium peroxide seed coating (grass 25% by weight, clover 5%) (2) as 1 plus guazatine fungicide (3) as 1 but using calcium carbonate (4) grass and clover seed dressed with guazatine (5) seed mixed with 100% by weight calcium peroxide granules and (6) untreated seed.

Cultivation treatments (split-plots) were (i) cultivation with spiked harrow or disc before drilling and (ii) no cultivation.

The old sward was sprayed with glyphosate at 1.44 kg ae/ha in 200 l water/ha 7 days before drilling at each site. An additional treatment was included at site G where the sward was sprayed 14 days before drilling untreated seed. The aim of the cultivation treatments was to open up the desiccated sward before drilling. A perennial ryegrass/white clover mixture was used at sites D, E and G and perennial ryegrass alone at site F. Seed rate of untreated seed ranged from 24 to 32 kg with rates of coated seed adjusted and the drill calibrated to sow equivalent number of seeds per unit area. A Moore Unidrill was used at each site. At all sites, slug pellets and frit fly insecticide were used. pH was corrected where necessary and adequate fertiliser applied.

RESULTS

Establishing grass and clover seedlings were counted at weekly intervals after drilling until tillering made this too difficult. Grass seedlings continued to emerge up to 4 weeks after drilling in 1980 (Table 2) and for a further 2 weeks at site C where soil conditions were dry. However, there was a 10 to 20% loss of plants between 2 and 4 weeks in the paraquat 7-and 0-day treatments at site A. At all sites establishment decreased as interval between spraying and drilling decreased. Only the longer intervals approached a target of 400 plants per m^2. Removal of killed sward by burning was beneficial at site A but surprisingly had little effect at B and C. Calcium peroxide seemed to inhibit establishment in the first two weeks at site A but showed some advantage in reducing loss of seedlings in the paraquat treatments. At this site calcium peroxide coating improved the mean establishment from 196 to 210 plants/m^2 but had no effect at C.

Table 2

Effect of herbicide spray - drill interval on numbers of grass seedlings 4 weeks after drilling at 3 sites (per m^2)

Herbicide	Spray-drill interval (days)	Site A	Site B	Site C
Glyphosate	28	-	394	299
Glyphosate	21	313	-	-
Glyphosate	14	162	379	255
Glyphosate	7	138	296	171
Glyphosate	0/1	128	-	168
Paraquat	28	-	414	242
Paraquat	21	207	-	-
Paraquat	14	93	369	275
Paraquat	7	45	290	202
Paraquat	0/1	44	-	147
Paraquat	14 (burn)	696	228	152
Glyphosate	14 (burn)	-	-	199
Glyphosate	14 (rotovate)	-	-	507
Paraquat (split)	14 + 7	-	-	306
	SED	± 52.9	± 69.3	± 54.1

Ground cover assessments using a point quadrat, recording first hits were made in the autumn and following spring (Table 3).

Table 3

Ground cover of sown species, 3 months after drilling (%)

Treatment		Site A	Site B	Site C
Glyphosate	28 day interval	-	65	60
Glyphosate	21 day interval	20	-	-
Glyphosate	14 day interval	10	35	43
Glyphosate	7 day interval	2	42	33
Glyphosate	0/1 day interval	6	-	21
Paraquat	28 day interval	-	59	51
Paraquat	21 day interval	1	-	-
Paraquat	14 day interval	1	28	45
Paraquat	7 day interval	0	34	27
Paraquat	0/1 day interval	0	0	24
Paraquat	14 days/burn	38	39	28
Glyphosate	14 days/burn	-	-	41
Glyphosate	14 days/rotovate	-	-	64
Paraquat	14 + 7 day split	-	-	38

Seedlings at site A did not develop vigorously and ground cover was poor in all treatments except for the burnt treatment and the glyphosate at 21 day interval. There was no improvement in spring and the trial was reseeded. At sites B and C, the 28 day interval was much better than all other treatments except the rotovated treatment at C. Spring assessments at these sites showed a similar pattern and when yields were taken in 4 cuts at site C, there was a tendency towards a decrease in yield of first cut as the interval between spraying and drilling decreased. Over the season, however, there was no significant yield difference between treatments but botanical separation showed a slightly lower ryegrass content and higher percentage of regrowth species on the paraquat treatments. The glyphosate/rotovation treatment had the highest ryegrass content.

The results of seed coating are shown in Table 4.

Table 4

Effect of seed treatment on number of grass seedlings 4 to 5 weeks after drilling at 4 sites, cultivations meaned (per m^2)

Treatment	Site D	Site E	Site F	Site G
1. Calcium peroxide coating	195	132	903	253
2. Calcium peroxide + fungicide	215	178	743	351
3. Calcium carbonate coating	191	137	720	249
4. Fungicide only	324	152	633	454
5. Calcium peroxide granules	189	210	770	405
6. Untreated seed	343	175	723	383
7. Untreated seed/14 day interval	-	-	-	490
SED	±57.9	±27.7	±82.0	±42.5

Untreated seed was better than all other treatment at site D with the calcium peroxide and calcium carbonate significantly reducing establishment. The effect was less marked at site E with the calcium peroxide granules slightly improving establishment but the seed coatings largely having an adverse effect. At site F the peroxide coating gave a significant improvement but other treatments were not significantly different from untreated seed. At G seed coating again had an adverse effect but fungicide alone significantly improved establishment.

Surface cultivation before drilling improved establishment at the three sites, significantly so at D and G (Table 5). There was no apparent interaction with seed treatment.

Table 5

Effect of cultivation on number of grass seedling 4/5 weeks after drilling at 4 sites, seed treatments meaned (per m^2)

Treatment		Site D	Site F	Site G
Surface cultivation		297	790	393
No cultivation		189	710	346
	SED	± 15.3	± 46.0	± 12.2

Clover establishment was insignificant in any treatment at site D. At site E all seed treatments reduced establishment below the 16 plants/m^2 control plots. Clover was not sown at site F. At G all seed treatments improved establishment of white clover from 9 plants/m^2 with untreated seed to 30/m^2 with calcium peroxide coating and 41 plants/m^2 with guazatine. Cultivation further increased clover establishment by an average of 33%. A similar pattern emerged from later assessment of ground cover and first harvest yields.

DISCUSSION

The pattern on interval between spraying and drilling emerging at sites A to C confirms previous work (Davies et al, 1980). A minimum of 14 days appears necessary and an even longer interval is usually of benefit. The deleterious effect of paraquat on emerging seedlings sometimes apparent is a disadvantage for this chemical. Removal of old sward by burning usually improves establishment but surprisingly had little effect at two of these sites. Rotovation following sward desiccation had a marked effect and confirms previous work (Cromack et al., 1978).

The results of seed coating were variable. Calcium peroxide showed a deleterious effect at sites D, E and G, little effect at A and C and improved establishment at F. This latter result corresponds to results reported by Davies and Davies (1981). There is no clear explanation for this variable effect although it could be associated with amount of rainfall and soil moisture immediately after drilling. Most sites had dry soil conditions at drilling. Site F, while relatively dry at drilling, had 26 mm rainfall in the first week after drilling and 53 mm in the second. Rainfall in the equivalent period at other sites was lower and estimated soil moisture deficits were higher. Work elsewhere (J. H. Ollerenshaw, personal communication) also indicates a slight deleterious effect of calcium peroxide seed coating in a dry lowland loam soil but a marked improvement in establishment (up to 80%) by calcium peroxide coating in wetter upland peat and brown earth soil, and in waterlogged peat. The physical effect of the seed coating might inhibit absorption of water for germination in dry conditions but the presence of calcium peroxide has some advantage if water is plentiful or in surplus. Calcium peroxide as a granular mix had a variable effect. The variable effect on clover is difficult to explain. In these trials calcium carbonate coating had a similar effect to calcium peroxide, when soil conditions were dry, but no advantage in wetter conditions. Fungicide had a variable effect.

Minimal surface cultivation before drilling showed a marked improvement at all sites. The effect of this treatment is worth investigating further as it would be a fairly simple operation to use at farm level. Seed treatment, on the other hand, requires further detailed research.

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REFERENCES

Cromack, H. T. H.; Davies, W. I. C.; Rowlands, A.; Prytherch, E. I.; Davies, J. (1978). The replacement of old swards using herbicides and cultivation techniques. Proceedings 1978 British Crop Protection Conference - Weeds, 2, 333-339.

Davies W. I. C.; Jackson, M.V.; Johnson, J. (1980). Direct drilling of grass and clover into chemically destroyed sward. Proceedings 1980 British Crop Protection Conference - Weeds, 2, 495-502.

Davies, W. I. C.; Davies, J. (1981). Varying the time of spraying with paraquat or glyphosate before direct drilling of grass and clover seeds with and without calcium peroxide. Grass and Forage Science, 36, 65-69.

Habeshaw, D. B. (1980). Indigenous growth and germination inhibitors in grasses and their role in grass survival and pasture establishment. Grass and Forage Science, 35, 69-70.

Lynch, J. M. (1978). Production and phytotoxicity of acetic acid in anaerobic soils containing plant residues. Soil Biology and Biochemistry, 10, 131-135.

Squires, N. R. W.; Elliott J. G. (1972). Surface organic matter in relation to the establishment of fodder crops in killed sward. Proceedings 11th British Weed Control Conference, 1, 342-347.

THE EFFECT OF CONTROLLING VOLUNTEER CEREALS, POA TRIVIALIS AND RYEGRASS SEEDLINGS ON THE SEED YIELD OF PERENNIAL RYEGRASS

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Summary. Various herbicides were used in three trials for controlling volunteer cereals, *Poa trivialis* and ryegrass seedlings in perennial ryegrass seed crops. Autumn treatments gave the best control of volunteer wheat and increased seed yield by an average of 6.5%. In the second experiment spring barley was controlled by all treatments while *P. trivialis* was best controlled by TCA/ethofumesate. Seed yield increases of 11 to 21% were recorded, the latter from the TCA/ethofumesate treatment. There were no significant yield increases following the control of volunteer ryegrass seedlings and treatments which continued to show crop damage in the spring tended to reduce seed yield. TCA, ethofumesate, endothal, dalapon, atrazine, chlorpropham, diuron.

INTRODUCTION

Volunteer cereals and *Poa trivialis* are extremely common in herbage seed crops grown in the UK (Evans and Yates,1980). In 1981, 30% of crops in Hampshire had at least 1 plant/m^2 of volunteer cereals and 55% had such levels of *P.trivialis* (MAFF,1981). While chemicals such as ethofumesate offer control of these weeds (Hammond *et al.*, 1976) the cost (over £60/ha) may be prohibitive. In addition, because *P.trivialis* may germinate throughout a mild winter (Oswald,1981) interest has increased in the use of more frequent applications of cheaper chemicals like TCA and dalapon.

The decline in seed yield of second year as opposed to first year crops (A.W.Evans, personal communication) may be associated with massive shedding of ryegrass seeds which germinate after harvest and compete with the existing sward. If so, adequate control of volunteer seedlings may incline farmers to keep seed production fields down for longer than one year.

This paper summarises the results of three experiments undertaken between 1979 and 1981 to determine the effects of controlling the weeds mentioned above on the seed yield of perennial ryegrass crops.

METHOD AND MATERIALS

All three experiments were designed as randomised blocks with three replicates. The plots were combine harvested. Details of the sites and management are given in Table 1. The soil type was a silty loam at all three sites.

Table 1

Details of experimental sites and management

	Experiment 1	Experiment 2	Experiment 3
Location	Tufton Warren Whitchurch, Hants	Leckford Estates, Leckford, Hants	Manor Farm Upton Grey, Hants
Cultivar	S321	Melle	Meltra
Autumn management	Crop direct-drilled at 11 kg/ha, 11 Sept.1979 after minimal cultivation of winter wheat stubble. 75:63:63 kg/ha N:P_2O_5:K_2O applied at sowing	Crop direct-drilled at 12 kg/ha, 22 Aug.1980 into burnt stubble (spring barley). 55:65:75 kg/ha N:P_2O_5:K_2O applied in seedbed and 65 kg/ha N on 25 Nov.1980	Second year crop harvested in Aug. 1980. 47:85:77 kg/ha N:P_2O_5:K_2O applied autumn 1980
Spring management	50 kg/ha N applied mid March and 89 kg/ha mid April 1980	64 kg/ha N applied 24 March and 116 kg/ha on 21 April 1981	64 kg/ha N applied 19 March, 61 kg/ha on 7 April and 32 kg/ha on 30 April 1981
Harvested	12 Aug.1980	26 Aug.1981	21 Aug.1981

Experiment 1. Control of volunteer wheat. Details of herbicide treatments are shown in Table 2. Plot size was 4 x 30 m and all treatments were applied with a modified Oxford Precision sprayer using a 2 m boom with 8002 T jets in 225 l/ha water.

Table 2

Treatments and spray timings used in experiment 1

Chemical	Rate, kg/ha ai	Product	Rate, per ha	Date applied
Unsprayed				
TCA/dalapon	5.2	Teedal	7.0 kg	13 March 1979
TCA/dalapon	5.2	Teedal	7.0 kg	22 April 1979
Ethofumesate	2.0	Nortron	10.0 l	29 October 1979
TCA	4.6	Tecane	5.0 kg	29 October 1979
TCA	7.4	Tecane	8.0 kg	29 October 1979
TCA +	4.6	Tecane +	5.0 kg	29 October 1979
ethofumesate (sequential)	1.0	Nortron	5.0 l	21 November 1979
TCA +	4.6	Tecane +	5.0 kg	29 October 1979
ethofumesate (tank mix)	1.0	Nortron	5.0 l	
Dalapon	2.0	PP Dalapon	2.4 kg	22 April 1980

Wheat heads were counted in July 1980 within three 50 x 50 cm quadrats per plot, concentrated in the wheat swaths. Fertile tillers were assessed taking six counts of two adjacent 20 cm rows. Visual scores and percentage ground cover of crop and weed were also assessed. After harvest, samples were sieved to determine trash content. The 1000 seed weight and % germination were assessed according to official procedures.

Experiment 2. Control of volunteer barley and *P.trivialis*. The treatments (Table 3) were applied in 225 l/ha water using a CP3 knapsack sprayer with 00 fan nozzles. Plot size 3.65 x 50 m.

Table 3

Herbicide treatments and timings used in experiment 2

Chemical	Rate, kg/ha ai	Product	Rate, per ha	Timing
Unsprayed				
Endothal +	0.76	Herbon Pennout	4.0 1)	8 December 1980
wetter		Agral 90	1.0 1)	
Endothal	1.14	Herbon Pennout	6.0 1	8 December 1980
Ethofumesate	2.0	Nortron	10.0 1	5 December 1980
TCA +	4.6	Tecane	5.0 kg	5 December 1980
ethofumesate	1.0	Nortron	5.0 1	18 December 1980
Endothal +	0.76	Herbon Pennout	4.0 1)	2 February 1981
wetter		Agral 90	1.0 1)	
Endothal	1.14	Herbon Pennout	6.0 1	2 February 1981

Assessments of crop and weed ground cover were made throughout the winter and spring. Heads of *P.trivialis* were counted in June 1982 using four quadrats 50 x 50 cm per plot. After harvest, samples were sieved to determine trash content and the 1000 seed weight was assessed.

Experiment 3. Control of volunteer ryegrass seedlings in second year crops. All treatments (Table 4) were applied with a modified Oxford Precision sprayer in 225 l/ha water using a 2 m boom with 8002 T jets. Plot size was 4 x 25 m.

Table 4

Herbicide treatments used in experiment 3

Chemical	Rate kg/ha ai	Product	Rate, per ha
Unsprayed			
TCA	4.6	Tecane	5.0 kg
TCA	7.4	Tecane	8.0 kg
Atrazine +	1.5	Vectal)	3.0 1
adjuvant oil		Fyzol 11E)	5.0 1
Chlorpropham	2.5	CIPC	6.25 1
Diuron	1.7	Karmex	2.1 kg
Trifluralin/linurin +	1.7/0.8	Chandor)	7.0 1
paraquat	0.1	Gramoxone)	0.5 1
Dalapon	0.8	PP Dalapon	1.0 kg

Assessments were made throughout the winter on densities of crop, seedlings and grass weeds, especially *P. trivialis*. Fertile tillers were counted in three 20 x 20 cm quadrats per plot. At harvest samples were taken for assessment of trash content and 1000 seed weight.

RESULTS

Experiment 1. Control of volunteer wheat. All treatments reduced the number of wheat heads, with best control resulting from autumn treatments (Table 5). Complete control was achieved with the higher level of TCA and the TCA/ethofumesate treatments.

Table 5

The effects of single, sequential and mixtures of herbicide treatments on numbers of wheat heads in July, % trash in harvested sample, fertile tillers, clean seed yield and thousand seed weight

Herbicide	Rate, kg/ha	Month of spraying	Wheat heads/m^2	% large trash	Fertile tillers/m^2	Seed kg/ha	1000 seed weight, g
Unsprayed	-	-	122	21	1700	1480	1.56
TCA/dalapon	5.2	March	24	8	2220	1493	1.57
TCA/dalapon	5.2	April	80	20	1860	1378	1.53
Ethofumesate	2.0	Oct.	5	9	2427	1552	1.60
TCA	4.6	Oct.	19	7	2355	1681	1.57
TCA	7.4	Oct.	0	7	2329	1628	1.56
TCA/ethofumesate (sequential)	4.6/ 1.0	Oct./ Nov.	0	6	2330	1519	1.58
TCA/ethofumesate (tank mix)	4.6/ 1.0	Oct.	0	7	2891	1502	1.59
Dalapon	2.0	April	44	12	1772	1449	1.53
SED			$\pm$12.7	$\pm$2.8	$\pm$187	$\pm$80	

All autumn-applied treatments gave increases in clean seed yield, adjusted to 90% DM (Table 5). This increase was associated with an increase in fertile tillers. The tank mix of TCA/ethofumesate gave a massive increase in fertile tillers but retarded crop growth and delayed ear emergence. The April treatments resulted in small, non-significant reductions in yield. Differences in 1000 seed weight were not significant.

Experiment 2. Control of volunteer barley and *P. trivialis*. The December endothal treatments, applied under cold conditions, gave a complete kill on the barley within a few days but caused some check to crop growth, particularly the 4 l/ha + wetter treatment (Table 6). The TCA/ethofumesate and ethofumesate treatments worked much more slowly and had little effect on the crop. The February treatments of endothal did not appear to damage the crop. All treatments gave a significant reduction in *P.trivialis* inflorescences with the TCA/ethofumesate giving the best control.

Table 6

The effect of herbicides on ground cover of crop and weeds in May and control of P.trivialis in June

Chemical,date	Rate kg/ha	% ground cover: Ryegrass	Barley	Poa.	Poa trivialis: Head/m^2	% control
Unsprayed	-	45	3	46	931	-
Endothal) wetter) Dec.	0.76	61	0	29	655	30
Endothal Dec.	1.14	82	0	4	345	63
Ethofumesate Dec.	2.0	85	0	9	423	55
TCA) ethofumesate) Dec.	4.6 1.0	83	0	3	73	92
Endothal) wetter) Feb.	0.76	81	0	3	223	76
Endothal Feb.	1.14	79	0	12	389	58
SED		±6.5	-	±8.2	±119	

All herbicide treatments gave a significant increase in seed yield over the control (Table 7). The TCA/ethofumesate treatment gave the highest seed yield and lowest trash content.

Table 7

The effect of herbicides on the clean seed yield (90% DM), trash content and 1000 seed weight of perennial ryegrass

Chemical	Rate kg/ha	Seed kg/ha	Trash: Large %	Small%	1000 seed weight, g.
Unsprayed	-	1650	3.93	26.41	1.52
Endothal) + wetter) Dec.	0.76	1826	3.38	23.61	1.52
Endothal Dec.	1.14	1974	3.23	19.14	1.42
Ethofumesate Dec.	2.0	1886	2.97	22.63	1.51
TCA +) ethofumesate) Dec.	4.6 1.0	1991	4.64	17.21	1.45
Endothal +) wetter) Feb.	0.76	1920	3.64	18.84	1.51
Endothal Feb.	1.14	1941	3.55	22.57	1.43
SED		±71.2	±0.43	±2.12	±0.06

Experiment 3. Control of volunteer ryegrass seedlings in second year crops. All treatments reduced seedling numbers, with initial effects assessed 5 weeks after spraying still being apparent the following spring (Table 8). Difficulty in applying diuron resulted in a patchy effect. Treatments having most effect on the seedlings, viz. atrazine + oil, diuron and trifluralin/linuron/paraquat, also caused considerable crop damage, although this declined with time.

Table 8

The effects of herbicides on the ground cover of crop, volunteer ryegrass seedlings and P.trivialis

Herbicide	Rates kg/ha	Ground cover % recorded in: Oct.1980 Crop	Seed-lings	Poa	April 1981 Crop	Seed-lings	Poa
Unsprayed	nil	45.3	22.9	1.1	59.7	30.8	3.9
TCA	4.6	42.3	16.9	1.6	76.5	15.8	0.3
TCA	7.4	46.1	9.9	1.5	66.6	9.2	5.0
Atrazine + adjuvant oil	1.5	50.7	3.4	1.5	59.9	2.5	8.3
Chlorpropham	2.5	48.3	11.1	1.7	74.5	1.2	3.2
Diuron	1.7	50.7	2.6	1.7	54.0	2.8	10.4
Trifluralin/ linuron + paraquat	1.7/ 0.8 0.1	49.8*	0.0	0.0	21.8	0.3	4.7
Dalapon	0.8	43.1	17.2	2.1	72.7	16.3	2.7
SED					±8.7	±3.6	±3.1

*still dying

Treatments showing crop damage in spring (diuron,trifluralin/linuron + paraquat and atrazine) yielded less than the control. Yield responses of other treatments were not significant. The only treatment which retarded maturity (expressed by moisture content at harvest) was the trifluralin/linuron + paraquat. There was no effect on 1000 seed weight.

Table 9

The effect of herbicide on fertile tiller numbers, clean seed yield (90%DM) and 1000 seed weight (90%DM)

Herbicide	Rate, kg/ha	Fertile tillers/m^2	Seed, kg/ha	1000 seed weight, g
Unsprayed	nil	2208	2186	2.77
TCA	4.6	2750	2297	2.62
TCA	7.4	2450	2252	2.70
Atrazine + adjuvant oil	1.5	1958	1997	2.72
Chlorpropham	2.5	2283	2297	2.66
Diuron	1.7	2242	1867	2.66
Trifluralin/linuron + paraquat	1.7/0.8 0.1	1692	1748	2.75
Dalapon	0.8	2941	2278	2.66
SED		±429	±113	±0.10

DISCUSSION

Almost complete control (96%) of volunteer wheat was achieved by 2 kg ethofumesate/ ha, the commercially recommended rate. However, the mixture of 5 kg TCA and 1 kg ethofumesate, applied either sequentially or as a tank mix, gave 100% control, as did the 8 kg TCA, although the latter chemical can give variable results (Oswald 1979). Spring treatments, despite effecting some control of the wheat, did not increase seed yield, confirming the need to remove cereal competition in early autumn, especially if spring treatment is likely to result in a check in the crop. On the other hand, the presence of a small, yet undefined, level of a stiff strawed cereal may delay the adverse effects of lodging (Hebblethwaite et al., 1980) and result in greater seed set.

In experiment 2 volunteer spring barley was controlled effectively by all treatments. A particular advantage of the endothal treatment was rapid knockdown, but the chemical is a schedule II poison and in more recent work (unpublished) it has not performed as well. Poa trivialis, however, was not fully controlled by any treatment, although a significant increase in clean seed yield was achieved by all chemicals. The competitive effect of the weed, allied to difficulty in cleaning of seed samples, can result in losses of up to 33% of seed yield (Oswald amd Hagger, 1980). Although in this case maximum response was only 20% from a massive infestation, all treatments gave an economic increase in yield. Once again the most successful was the TCA/ethofumesate treatment. This treatment is now being applied on a wide scale in Hampshire and also in the Netherlands (Sijtsma, 1980).

In experiment 3, response in terms of seed yield was not significant. Seedlings were reduced, especially with the chlorpropham, atrazine, diuron and trifluralin/linuron + paraquat treatments, although the latter three treatments also caused considerable crop damage. It is suggested that there may be other benefits in terms of improved combine performance from seedling control. Certainly in this experiment chemical control of volunteer seedlings was achieved, yet the seed yield response was marginal and negative effects were found with those chemicals most successful at controlling the seedlings. It can therefore be concluded that volunteer ryegrass seedling control may not give an economic increase in seed yield. Moreover there is a risk of a negative effect, and any benefits are only likely to occur from inproved combine efficiency.

The three experiments indicate the likely benefits from the use of herbicide to control specific weed problems. There is need for more work in the economic significance of their control and the use of the chemicals described on a wider scale especially when volunteer cereals and P.trivialis are found together.

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REFERENCES

Evans, A.W.; Yates, C.W. (1980). Preliminary report of a survey of the important weeds causing problems in herbage seed crops in England and Wales - 1978 season. National Institute of Agricultural Botany, Cambridge.

Hammond, C.H.; Griffiths, W.; van Noogstratan, S.D.; Whiteoak, R.J. (1976). The use of ethofumesate in grass seed crops. Proceedings 13th British Weed Control Conference, 2, 657 - 663.

Hebblethwaite, P.D.; Wright, D; Noble, A. (1980). Some physiological aspects of seed yield in Lolium perenne (perennial ryegrass). In: Seed Production, (Proceedings of University of Nottingham 28th Easter School) P.D. Hebblethwaite (Ed), London: Butterworths, 71 - 90.

Ministry of Agriculture, Fisheries and Food (1981). Hampshire weed survey in 1981 herbage seed crops. Agricultural Development and Advisory Service,Winchester.

Oswald, A.K. (1979). The use of TCA to control volunteer barley in ryegrass crops grown for seed. Proceedings 1978 British Crop Protection Conference - Weeds, 2 409 - 413.

Oswald, A.K. (1981). The use of sequential herbicide treatments to control Poa trivialis in two perennial ryegrass crops grown for seed. Proceedings 1980 British Crop Protection Conference - Weeds, 2 489 - 493.

Oswald, A.K.; Haggar, R.J. (1980). Weed control in ryegrass grown for seed. In: Seed Production, (Proceedings of University of Nottingham 28th Easter School) P.D. Hebblethwaite (Ed), London: Butterworths, 121 - 135.

Sijtsma, R. (1980). Volunteer wheat in ryegrass seed crops: damage and control. 32nd International Symposium on Crop Protection, 1119 - 1129.

SELECTIVE CONTROL OF ULEX GALLII AND ULEX EUROPAEUS (GORSE) IN A CALLUNA VULGARIS (HEATHER) DOMINANT HILL SWARD

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Summary. Four rates of triclopyr ester were applied to a Calluna vulgaris/ Ulex gallii and Ulex europaeus association in July, September and November 1979 (experiment 1) and in July and September of 1980 (experiment 2). In experiment 1, 0.48 kg ai/ha of triclopyr in September gave the best kill of Ulex sp. with the least damage to Calluna sp. Treatments in experiment 2 were designed to define more accurately the optimum rate of triclopyr for the selective control of the Ulex sp. The effects of these treatments, assessed in July 1981, confirmed the 1979 trial that 0.48 kg ai/ha applied in September gave the most effective kill of Ulex sp. with the least damage to Calluna sp. The 0.24 kg ai/ha rate did not give such a good kill of Ulex sp.

INTRODUCTION

Considerable areas of hill land dominated by Calluna vulgaris (heather) and Erica tetralix (cross-leaved heather) are being invaded by Ulex gallii and Ulex europaeus (gorse). This is particularly true in areas grazed largely by sheep who avoid grazing the prickly foliage of Ulex sp. Invasion by Ulex sp. may also occur under mixed grazing by cattle and sheep. Once established it is very difficult to eradicate. Selective control of Ulex sp. would greatly enhance the quality and quantity of the forage for grazing.

Pot experiments by Turner and Richardson (1978) have shown that triclopyr as the amine salt gave good control of Ulex europaeus but was not very active against Calluna vulgaris. In forestry trials McCavish (1980) reported that triclopyr ester was particularly effective in controlling Ulex europaeus and Ulex gallii and Sarothamnus scoparius (broom) and tended to be more effective than 2,4,5-T. Gilchrist (1980) also reporting on forestry trials, found that triclopyr amine was more active against Ulex sp. when applied in July than in August. In these trials, too, triclopyr ester salt gave superior overall woody weed control to triclopyr amine. This paper reports the effect of date and rate of application of triclopyr ester in selectively controlling Ulex sp. in a Calluna sp. dominant hill sward.

METHODS AND MATERIALS

The site was on Exmoor at an elevation of 380 m and an annual rainfall of 1,500 mm. The soil was peat overlying Devonian shales and slates and was free draining. Calluna vulgaris was the dominant vegetation occupying about 60% ground cover. The sub-dominant species was mainly Ulex gallii with some Ulex europaeus occupying 20% ground cover. These species varied in height from 0.3 to 0.6 m. Grass species present included Festuca rubra, Nardus stricta, Agrostis stolonifera, Anthoxanthum odoratum, Holcus lanatus and Poa sp. Broad leaved weeds included Pedicularis sylvatica, Potentilla tomentilla and Galium saxatile. Carex panicea, Carex pilulifera and Luzula compestris were also present.

Triclopyr was used in both experiments as an oil soluble, water emulsifiable, low volatile ester formulation containing 480 g ai/l of triclopyr. In experiment 1, triclopyr was applied at 0.48, 0.96 and 1.92 kg ai/ha in July, September and November 1979. The rates in experiment 2 were reduced to 0.12, 0.24 and 0.48 kg ai/ha, applied only in July and September 1980. Treatments were applied in 1,000 l/ha of water at a pressure of 207 kPa using a Drake and Fletcher knapsack sprayer.

Plot size was 11 x 3.6 m, replicated 3 times and laid out in a randomised block. Control of Ulex sp. and C. vulgaris was assessed visually in the year after spraying, using a 0-10 scale where 0 = completely healthy and 10 = complete kill.

RESULTS

All rates of triclopyr applied in July and September 1979 gave an excellent control of Ulex sp. (Table 1). At the two highest rates, the herbicide was also very active against Calluna sp. giving a very high degree of kill particularly when applied in July. The selective effect on the Calluna sp. was very marked at the 0.48 kg ai/ha applied in September. Treatments applied in November showed far less activity against the Ulex sp. and very little activity on Calluna sp.

Table 1

Experiment 1. Effect of triclopyr applied on 3 dates on kill of Ulex sp. and C. vulgaris assessed 7 July 1980 (%)

Triclopyr rate, kg ai/ha	Date applied, 1979: 12 July		4 September		21 November	
	Ulex sp.	C. vulgaris	Ulex sp.	C. vulgaris	Ulex sp.	C vulgaris
0.48	100	51	100	21	41	7
0.96	100	95	100	60	61	11
1.92	100	98	100	97	61	18
Control	13	2	11	2	13	5

Triclopyr was very fast acting giving almost complete foliage browning within a month of application from the July and August treatments. The effect of the November time of application could not readily be distinguished from normal die-back of the foliage. Triclopyr at the 1.92 kg rate was very damaging to the indigenous grass species and broad leaved weeds. At the 0.96 kg rate and below there did not appear to be any loss of plant of these species. It was very difficult to carry out a detailed assessment of the grass and broad leaved weed species as the majority were growing beneath the canopy of the Ulex and Calluna spp.

Table 2

Experiment 2. Effect of triclopyr applied on 2 dates on kill of *U. europaeus* and *C. vulgaris* assessed on 3 July 1981

Triclopyr rate, kg ai/ha	Date applied, 1980: 21 July		2 September	
	Ulex sp.	*C. vulgaris*	*Ulex sp.*	*C. vulgaris*
0.12	77	2	48	2
0.24	87	4	80	2
0.48	95	27	93	5
Control	2	2	2	2

Encouraged by the selective effect of triclopyr from the results of the 1979 experiment, a further experiment was designed in 1980 to define more precisely the optimum rate of triclopyr for selective control of *Ulex sp*. These results (Table 2) confirmed the 1979 experiment that the 0.48 kg rate applied in September gave the greatest kill of *Ulex sp*. with the least damage to *Calluna sp*. Triclopyr applied in July at this rate was too damaging to the *Calluna sp*. The indigenous grasses and weeds present survived all rates and dates of application of the herbicide.

Further assessments were made of the 1979 treatments in July 1981 (Table 3). These confirmed the 1980 assessments that the low rate of triclopyr applied in September gave a very good kill of the *Ulex sp*. with little damage to the *Calluna sp*. The main difference from the 1980 assessments is the considerably less kill of the *Calluna sp*. from 0.96 kg rate applied in September. This may be due to the recovery growth of the *Calluna sp*. indicating that the 0.96 kg rate in September was not as damaging as the earlier assessments indicated. These results also suggested that the November applications of triclopyr were more damaging to the *Ulex sp*. than the 1980 assessments indicated. The competitive effect of the *Calluna* and grass species may also have been a contributory factor in reducing the ground cover of the *Ulex sp*.

Table 3

Experiment 1. Effect of triclopyr applied on 3 dates on kill of *Ulex sp*. and *C. vulgaris* assessed 7 July 1980 (%)

Triclopyr rate, kg ai/ha	Date applied, 1979: 12 July		4 September		21 November	
	Ulex sp.	*C. vulgaris*	*Ulex sp.*	*C. vulgaris*	*Ulex sp.*	*C. vulgaris*
0.48	97	40	95	8	53	7
0.96	97	90	100	20	78	10
1.92	98	98	100	83	88	8
Control	2	2	2	2	5	2

DISCUSSION

In these experiments triclopyr ester applied at 0.48 kg ai/ha in September was very effective in selectively controlling *Ulex sp*. in hill vegetation where *Calluna sp*. was the dominant vegetation. Of great importance, too, at the rate applied, triclopyr ester resulted in little or no damage to the underlying indigenous grass vegetation. A year after treatment the area occupied by *Ulex sp*. was rapidly being colonized by indigenous grasses and by some of the broad leaved weeds. Removal of the Ulex sp. has resulted in a more efficient utilization of this moorland vegetation by the grazing animals.

The selective effect of the triclopyr at the 0.48 kg rate in September was sustained two years after the treatment was applied (Table 3). Results from Table 2 suggest that an even lower rate of triclopyr may be sufficient to arrest any recolonization of Ulex sp. at a later date. Further work will be necessary to substantiate this possibility.

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REFERENCES

Gilchrist, A.J. (1980). Control of woody weeds in forestry with triclopyr. Proceedings of the Conference on Weed Control in Forestry, University of Nottingham, 249-256

McCavish, W.J. (1980). Herbicides for woody weed control by foliar application. Proceedings of the 1980 British Crop Protection Conference - Weeds, 729-737.

Turner, D.J. & Richardson, W.G. (1978). Pot experiments at the Weed Research Organisation with forest crop and weed species. Technical Report Agricultural Research Council Weed Research Organisation 1978, (46), pp. 16.

ECONOMIC EVALUATION OF WEED CONTROL IN GRASSLAND

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Summary. The difficulties of conducting economic evaluations of weed control in grassland are examined. In particular, the problem of valuing increases in herbage production from controlling weeds is reviewed. It is concluded that, for the purposes of evaluating the general economic implications of research findings, a working value for grass of 3.5 pence per kg d.m. may be employed, though this figure is not appropriate for all research situations. The necessity of taking account of the feeding value of many weed species is stressed, along with the need to consider both the immediate and the long-term benefits of weed control. Above all, it is concluded that the problems of conducting economic evaluations of weed control in grassland may be less conceptual and arise more from lack of data.

INTRODUCTION

The increased yields of arable crops due to control of weeds can be ascertained from field trials and it is a relatively easy step to translate the extra output into farm profits. The same process is so involved in the case of grassland that it is seldom attempted. Difficulties faced in evaluating the benefits of weed control in grassland include:

i) In contrast to the arable situation, species commonly considered as 'weeds' in grassland may not differ agronomically or botanically in any substantial degree from the crop itself. Thus, while the wild oats invading a field of spring barley are of no value to the cereal grower, the same is not true of such 'weed' grasses as common bent (*Agrostis tenuis*) or rough meadow-grass (*Poa trivialis*) from the viewpoint of the livestock producer. These grass weeds may depress yields obtained from a predominantly perennial ryegrass (*Lolium perenne*) sward, but they themselves have a feeding value. Accordingly, some of the grass weeds may have an economic value.

ii) Grass is not a traded commodity. Apart from small quantities of dried grass or hay, very little grass is sold off the farm and so it does not have a directly quotable price in the sense that barley or wheat does. Hence, the value of grass has to be imputed from its contribution to livestock production.

iii) As grass only has a value if it can be efficiently converted into marketable animal products, the value depends on the management skills of the farmer. For instance, where the level of grass utilisation is low, the extra grass production achieved through weed control may be comparatively worthless. Thus, in contrast to arable crops, evaluation of the probable benefits of weed control in grassland needs to take into account both the effect on crop (grass) yields and the utilisation of the crop by livestock. The problem facing the analyst is that there is no universally accepted procedure for converting a given increase in grass production into a given increase in livestock output.

These complications underline the difficulty of preparing convincing economic arguments for weed control in grassland. Therefore the rest of this paper attempts to provide a general framework within which the economic evaluation of specific weed problems may be approached. Following a brief definition of what is meant by a weed, an examination is made of ways of quantifying the physical effects of weeds on livestock production. This is followed by a discussion of the problems involved in ascribing a value to changes in herbage production arising from weed control. Finally, some observations are made on the approach which should be used to establish the cost effectiveness of weed control. Although these principles are illustrated with reference to problems of weed control in established lowland pastures, they are generally applicable to problems of weed infestation.

CONCEPT OF A WEED

At the outset it is useful to define what is meant by a weed. Wells (1974) defined a weed as a species whose presence resulted in a reduced economic output. This is a somewhat tautological definition given that the aim of this study is to determine the economic impact of certain species. Accordingly, weeds are taken to be simply species which are generally considered to the undesirable in grassland. In these terms it is possible to distinguish three broad groups of lowland pasture weeds:-

i) Broad-leaved weeds of which the most important according to Peel and Hopkins (1980) are creeping thistle (Cirsium arvense), buttercups (Ranunclulus spp.), docks (Rumex crispus) and R. obtusifolius) and ragwort (Senecio jacobaea).

ii) 'Undesirable' grasses of which the most notable are couch (Agropyron repens), creeping soft grass (Holcus mollis), soft brome (Bromus mollis), the barley grasses (Hordeum spp.) and tussock-grass (Deschampsia caespitosa).

iii) As well as the grass species mentioned above, there are a number of other species found in grassland which few farmers today would consider sowing. The most common of these are common bent (Agrostus tenuis), creeping bent (Agrostus stolonifera), Yorkshire-fog (Holcus lanatus), annual meadow-grass (Poa annua), rough meadow-grass (Poa trivialis) and red fescue (Festuca rubra).

IMPACT OF WEEDS ON LIVESTOCK PRODUCTION

Relatively few grazing studies, which permit a direct estimate of the impact of weed control on livestock production, have been conducted. Notable exceptions are the studies by Mudd (1971), Elliott et al. (1978) and Haggar and Elliott (1978). Hence, excluding poisonous weeds such as Senecio jacobaea, the effects of weed infestation on animal output have to be estimated indirectly from the effects on dry matter yield and digestibility of the crop. However, unlike weed infestation in arable crops, the effects are frequently not straight forward. Thus, although the presence of 'weed' species may depress the yield of the 'forage' species, the weed species themselves may be useful to livestock. Thus, the overall yield of digestible material for the livestock may decline less than the decline in the forage crop yield. In addition, the weeds may exploit a different part of the sward's environment to that exploited by the forage crop, so that a mixture of the two species may give a higher dry-matter yield than the forage species grown in monoculture.

Both these points are well illustrated by studies on the third group of weeds, namely those comprising such species as Poa trivialis and Agrostis stolonifera. Haggar (1976) showed that, while some of the commonly occurring indigenous grasses do not have the same potential yield as perennial ryegrass (Lolium perenne), they have comparable digestibilities (Table 1). Furthermore, in another study on herbage yields of ryegrass swards invaded by Poa annua and P. trivialis Wells and Haggar (1974) found that herbage yields were about 15-20% higher on swards with 50% Poa compared to the pure ryegrass pastures. Likewise, work by Courtney and Johnston (1978) on the grazing behaviour of cattle on dock-infested grassland indicated that many grassland weeds have a feeding value which partially compensates for their depressive effect on the yield of the forage crop. Thus, they found that on the basis of the % of docks in the sward the % intake of docks at grazing in mid-season was about 85% that of grass. At the same time the docks were found to be about 80% as digestible as grass.

Table 1

Potential yield (kg d.m./ha) and digestibility (%) of some commonly occurring indigenous grass species relative to perennial ryegrass under conditions of high nitrogen and irrigation

	Annual yield	Digestibility
L. perenne	10962	65.4
H. lanatus	10857	69.0
F. rubra	9954	61.2
A. stolonifera	8283	65.4
P. trivialis	7838	61.2

Thus, in any economic evaluation of the impact of weeds on herbage production it is important to consider both the adverse competitive effects of weeds and also any positive contribution they may make to utilisable herbage production. These two effects may be summarised conveniently in terms of the effect of weeds on the total digestible organic matter (DOM) produced per hectare (Spedding, 1966). Let d_G and d_W represent the percentage digestibilities of the grass and weed species respectively and Y_G the potential yield of grass on a weed-free sward, then for a given level of weed infestation Y_W, the change in digestible organic matter produced (ΔDOM) relative to a weed-free sward is given by:

$$\Delta DOM = \left(\frac{d_G}{100}\right)Y_G - \left[(1 - r_W)\left(\frac{d_G}{100}\right)Y_G + \left(\frac{d_W}{100}\right)Y_W\right] \quad (1)$$

where Y_G and Y_W are expressed in kg d.m./ha and r_W is the proportionate reduction in Y_G caused by a level of weed infestation Y_W.

To translate the effect on herbage yields into an effect on animal production then requires information in particular on (i) the extent to which the weed is eaten by the stock and (ii) the degree to which the herbage is or would be utilised if the weeds were removed. If the weed is not eaten to any great extent, then the contribution of the weed to digestible organic matter may be ignored and the change in utilisable DOM is reduced to r_W $(d_G/100)Y_G$. In practice utilisation rates of herbage are less than 100%. Peel and Forbes (1979) in an extensive survey of permanent pasture noted that about 60% of grass grown was typically utilised. Accordingly, the percentage change in animal output can be expected to be smaller than the percentage change in DOM. However, the problem facing the analyst is that there is no generally accepted procedure for translating a given increase in herbage production into an expected increase in livestock output, so that difficulties may be encountered in valuing a given change in herbage production.

VALUING CHANGES IN HERBAGE PRODUCTION

Not being a traded commodity, the value of a change in grass production has to be imputed from its contribution to livestock output. This involves valuing the change in livestock production associated with the change in grass production and deducting from this figure costs. The residual net income then provides a measure of the value of the change in grass output. Since the value placed on grass is then very much a residual item it is not surprising that its apparent value changes according to the livestock activity being considered. Furthermore, the value of grass is likely to change over the season. For most livestock enterprises, both the availability of grass and demands for it are continually fluctuating and, in turn, the implied economic value of extra grass will vary according to the time of year. True, some grass may be transferred from one period to another in an effort to match supply and demand more efficiently, but this can only be done at a cost in the form of conservation or a deterioration in the feeding value of the standing crop. Thus, it is not possible to speak of a single value for grass, which is universally accepted, in the way that there is a single 'price' for feeding barley or soya.

The absence of a universally recognised value for grass presents considerable difficulties for researchers trying to evaluate the general economic consequences of their findings on weed control in grassland. In an unpublished paper Doyle and Elliott (1982) have attempted to circumvent this problem by trying to derive a 'representative' value for grass, which while not applicable in specific farm situations, may be used by researchers as a working value. The procedure employed has been to assess the apparent value of extra grass where it is used: (i) to increase the stocking-rate on dairy, beef and sheep enterprises; (ii) to reduce the dependence on alternative feeds, such as concentrates; (iii) to reduce the requirements for bought-in fodder, such as hay; (iv) to obviate the need to rent extra grassland; and (v) to release land for alternative enterprises, such as cereals or potatoes. In all cases it was assumed that only 60% of the extra grass produced would be utilised. The resultant values for grass in the field ranged from 2.6 to 6.4 pence per kg d.m., with a tendency to congregate around 3 to 4 pence per kg d.m. This suggested that in terms of valuing extra grass production a reasonable working value might be 3.5 pence per kg d.m. at 1982 prices.

It is important to recognise that this figure of 3.5 pence per kg d.m. is only a working value and that it cannot be used in all research contexts with impunity. In particular, implicit in this value is the assumption that the extra grass is utilised with 60% efficiency. This may be a reasonable assumption where the effect of controlling weed infestation is to increase grass production throughout the season. However, where the objective of research is principally to modify the seasonal pattern of grass production - by altering the timing of nitrogen usage for instance - this assumption is unlikely to be tenable. Where the increase in grass production occurs mainly in a period when availability of herbage already exceeds supply, the proportion of the extra grass utilised may be low and consequently the extra grass will have little value. In the contrary situation, where the increase in grass production occurs in a period of shortage the extra grass may be extremely valuable.

Also implicit in this valuation of grass is the assumption that sward production is setting the limit to livestock output per hectare. In particular farm situations the more immediate constraints on stocking rates and hence livestock production may be shortage of capital or labour or problems related to disease control. Clearly in these situations extra grass production may be of limited value. Nonetheless, for the purpose of evaluating the general implications of research findings for farming it seems reasonable to assume that livestock output is constrained by herbage production, whilst recognising that in specific instances other constraints may apply.

Accordingly, if it is accepted that 3.5 pence per kg d.m. is a representative value for grass in the field for the majority of experiments and field trials involving weed control, then it is possible to assess the annual benefits from controlling weed infestation without making explicit assumptions about the stocking rates. Returning to equation (1) it is now possible to directly express the change in digestible organic matter (ΔDOM) from eradicating weeds as a financial benefit (B). To do this it is necessary to convert the representative value for grass expressed per kg d.m. into a value per kg of digestible organic matter. Taking as a standard a digestibility of 65% and assuming that grass of this digestibility has a value of 3.5 pence per kg d.m., then this implies a representative value for digestible organic matter of 5.4 pence per kg. Accordingly equation (1) may be re-expressed as:

$$B = \left(\frac{p}{100}\right)\left\{\left(\frac{d_G}{100}\right)Y_G - \left[(1 - r_W)\left(\frac{d_G}{100}\right)Y_G + k\left(\frac{d_W}{100}\right)Y_W\right]\right\} \qquad (2)$$

where B = the net benefit from eradicating weeds, £/ha
p = value of digestible organic matter, pence/kg DOM
k = coefficient of selective preference for the 'forage' (grass) species.

Where the weed species is entirely rejected by the livestock regardless of its apparent digestibility, k equals 0. On the other hand, where the animals appear to eat the weed species as readily as the forage crop, k equals 1.

COST EFFECTIVENESS OF WEED CONTROL

Just as valuing changes in crop production following weed control is less straight forward in the grassland context compared to the arable situation, so is the evaluation of the cost effectiveness of weed control. Whereas with arable crops it is not unreasonable to confine attention to the current harvest year and simply consider the immediate increase in crop yields following weed control, this is unlikely to be satisfactory in the case of grassland. Firstly, not being an annual crop, the effect of chemical controls on weed infestation in subsequent years is likely to be as important to the livestock farmer as the immediate effects. Secondly, relative to the value of the crop the use of herbicides on grassland tends to be more expensive, so that the economic justification for herbicides may depend on both the long- and short-term implications. The approximate costs per hectare (excluding application) for herbicides commonly used on cereal crops and grass are shown in Table 2. The information for cereal weed sprays is adapted from Elliott (1978) and MAFF (1981a), while that for grassland herbicides is taken from MAFF (1981b). The costs per hectare have also been expressed in terms of the yield increase necessary to pay for the cost of the chemicals. The cereal costings have been based on a cereal yield of 5.5 t/ha at a price of £115/t (Nix, 1981). In the case of the grass costings, a typical yield of 8000 kg d.m./ha/year has been employed, while the marginal value for grass has been fixed at 3.5 pence per kg d.m. From Table 2 it would appear that, relative to the value of the crop, herbicides on grassland are two to three times more expensive than the equivalent cereal weed sprays.

Table 2

Weed control in grass and cereals; "Yield equivalents" at 1982 prices

Cereals

Herbicide	Cost £/ha	Cost as % of crop value
2-4D	3.50	0.5
Mecoprop	6.00	0.9
Paraquat	25.00	3.6
Chlortoluron	37.00	5.8
Difenzoquat	40.50	6.4
Methabenz-thiazuron	41.00	6.5
Isoproturon	44.00	7.0
Glyphosate	49.00	7.1

Grass

Herbicide	Cost £/ha	Cost as % of crop value
Mecoprop	3.50	1.3
Asulam	18.50	6.6
Methabenz-thiazuron	22.00	7.9
Paraquat	25.00	8.9
Ethofumesate	44.00	15.7
Glyphosate	49.00	17.5

The importance of considering not only the immediate but also the longer term effects of weed control in grassland is well illustrated by an unpublished attempt to simulate the long-term effects of using asulam to control dock infestations in grass swards (Doyle et al., 1982). Considering a sward in which docks initially accounted for 20% of the ground cover, then only about 40%

of the increase in grass production arising from a single application of 1.0 kg ai/ha of asulam was projected to occur in the first year. Rather more than 50% of the increase in grass production was realised in the second and third years following the application of the herbicide. However, simulating the long-term impact of weed control strategies requires information on rates of seeding, germination and mortality of the weed species. Unfortunately information on the population biology of weeds is comparatively scarce (Attwood, 1980), while few experiments have documented the impact of weed control beyond the first two years. However, without the ability to predict the course of weed infestation over time, as Cussans (1980) and Attwood (1980) have observed it is difficult to make satisfactory recommendations on the level of weed infestation below which control is uneconomic. In the absence of information on the population biology of weed species, the danger of merely confining the cost-benefit analysis to the immediate costs and benefits is well illustrated by the study on dock infestations referred to previously. In this study it was found that, the costs of controlling docks exceeded the immediate benefits, up to quite high levels of infestation. Only if the benefits from improved grassland productivity in subsequent years were considered did control of dock infestation become an economic proposition.

The other major problem which has to be confronted in any assessment of the cost effectiveness of weed control is the uncertainty surrounding the response of weeds to control measures. Considerable variation in response to herbicides is evident in studies of weed control in grassland. Forbes et al. (1980) have reported significant differences between sites in the effectiveness of controlling Senecio jacobaea through spraying. Similarly, in a comparison of the response of docks to asulam at two sites, Oswald and Haggar (1976) found that the magnitude of the response could vary by a factor of two or more. Such differences in response are likely to mean the difference between control being worthwhile and uneconomic. Thus, it is important in any cost-benefit analysis that this variation in response is not disguised by assuming a fixed and certain response curve. For farmers in general the degree of variation in possible benefits from weed control will be as important as knowing what are the average expected benefits.

CONCLUSIONS

The principal conclusions to be drawn from this general survey are:-

i) Weeds in grassland may themselves have an economic value to the livestock farmer. Accordingly, an economic evaluation of weed control which solely focusses on the impact of the weed on the 'forage' crop may produce a false answer.

ii) Although there are conceptual difficulties in ascribing a value to the extra grass realised through weed control, it is suggested that a 'representative' value for grass of 3.5 pence per kg d.m. may be employed. This is equivalent to 5.4 pence per kg of digestible organic matter.

iii) Both the immediate and long-term benefits arising from weed control need to be considered. This requires greater availability of information on the population biology of weeds.

iv) Given the considerable variation in observed response of weeds to control measures, both between years and sites, it is important that the range in the response is explicitly recognised in any cost-benefit analysis.

v) The problems of conducting economic evaluations of weed control in grassland may be less conceptual and arise more from the lack of data. In particular, more information is needed on (a) the digestibility and palatability of weed species, (b) the competitive effects of many weed species and, above all, (c) the population biology of weeds.

REFERENCES

Attwood, P. J. (1980). Strategic planning for weed control: Eradication or containment. Proceedings 1980 British Crop Protection Conference - Weeds, 3, 833-838.

Courtney, A. D.; Johnston, R. T. (1978). A consideration of the contribution to production of Rumex obtusifolius in a grazing system. Proceedings 1978 British Crop Protection Conference - Weeds, 1, 325-332.

Cussans, G. W. (1980). Strategic planning for weed control - A researcher's view. Proceedings 1980 British Crop Protection Conference - Weeds, 3, 823-831.

Doyle, C. J.; Elliott, J. G. (1982). Evaluating the potential economic benefits of applying research results on grass. (Unpublished).

Doyle, C. J.; Oswald, A. K.; Haggar, R. J.; Kirkham, F. W. (1982). Economics of controlling Rumex obtusifolius in grassland. (Unpublished).

Elliott, J. G. (1978). The economic objectives of weed control in cereals. Proceedings 1978 British Crop Protection Conference - Weeds, 3, 829-839.

Elliott, J. G.; Dale, R. J.; Barnes, F. (1978). The performance of beef animals on a permanent pasture. Journal of the British Grassland Society, 33, 41-48.

Forbes, J. C.; Kilgour, D. W.; Carnegie, H. M. (1980). Some causes of poor control of Senecio jacobaea L. by herbicides. Proceedings 1980 British Crop Protection Conference - Weeds, 2, 461-468.

Haggar, R. J. (1976). The seasonal productivity, quality and response to nitrogen of four indigenous grasses compared with Lolium perenne. Journal of the British Grassland Society, 31, 197-207.

Haggar, R. J.; Elliott, J. G. (1978). The effects of dalapon and stocking rate, on the species composition and animal productivity of a sown sward. Journal of the British Grassland Society, 33, 23-33.

Ministry of Agriculture, Fisheries and Food (1981a). Weed Control in Cereals 1982. Alnwick: MAFF.

Ministry of Agriculture, Fisheries and Food (1981b). Weed Control in Grassland, Herbage Legumes and Grass Seed Crops 1981-82. Pinner: MAFF.

Mudd, C. H. (1971). The comparison of two farm-units managed under natural and artificial grassland. Proceedings 4th General Meeting of European Grassland Federation, Lausanne, Switzerland, 44.

Nix, J. (1981). Farm Management Pocketbook, 12th edition. Wye College, Univ. of London.

Oswald, A. K.; Haggar, R. J. (1976). The effect of asulam on two Lolium perenne swards containing Rumex obtusifolius. Weed Research, 13, 224-230.

Peel, S.; Forbes, T. J. (1979). Actual and potential production from permanent grass. In: Water Control and Grassland Productivity. Papers presented at the British Grassland Society Winter Meeting, 4 December 1979, 8.1-8.2. Hurley: The British Grassland Society.

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

Spedding, C. R. W. (1966). Weeds and animal productivity. Proceedings 8th British Weed Control Conference, 3, 854-860.

Wells, G. J. (1974). The biology of Poa annua and its significance in Grassland. Herbage Abstracts, 44, 385-391.

Wells, G. J.; Haggar, R. J. (1974). Herbage yields of ryegrass swards invaded by Poa species. Journal of the British Grassland Society, 29, 109-111.