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THE LONG-TERM BENEFITS OF BRACKEN (PTERIDIUM AQUILINUM (L) KUHN) REMOVAL WITH ASULAM ON HILL FARMS IN NORTHERN BRITAIN

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Summary Case studies are presented on the economics of applying asulam for *P. aquilinum* control and subsequent agricultural practice, involving six farms in N. England and Scotland.

It is concluded that, with the right kind of after-care suited to each particular hill farm, real benefits ensue and these mainly develop over a period of years after spraying.

INTRODUCTION

Bracken fern (*Pteridium aquilinum* in the U.K.) is a weed of hills and woodlands growing mainly in well-drained fertile soils. There are probably about 160,000 ha of *P. aquilinum*, mostly on rough grazing land, in Scotland (McKelvie and Scragg 1972-3) and an equivalent area elsewhere in the British Isles.

Trial results using asulam to control *P. aquilinum* have been extensively reported (Holroyd *et al* 1970, Scragg *et al* 1972, Soper 1972, Wasmuth 1973, Pink and Surman 1974), and it is reckoned that since the introduction of the chemical for this purpose in 1972, approximately 3,250 ha of land have been sprayed annually, mainly from the air. (Application problems are not dealt with in this paper).

The benefits of weed control in arable crops are fairly obvious: less competition for the crop for light, fertilizer, and moisture leading usually to higher yields and greater profit along with easier and cheaper harvesting. The financial benefits are comparatively easily measured, and with good management a reward is immediately reaped. By contrast, the costly removal of a stand of *P. aquilinum* on the hill does not bring immediate financial gain to the farmer, and to put a value on benefits such as increased stocking rates, easier stocking, herding and gathering, less harbour for ticks, removing a source of poisoning, healthier ewes, larger lambs and so forth, is very difficult.

In 1976 it was felt timely to visit representative farms where treatment of *P. aquilinum* had been carried out with asulam in order to collate the costs of spraying and after-care.

METHODS AND MATERIALS

The survey was carried out on six hill farms where sites had been aerially sprayed by commercial contractors in 1973 and 1974. The sites were from 4 to 60 ha and were located in Argyllshire, Galloway, and Cumbria, two sites in each region to give a range of topography, elevation, and rainfall.

The objective of the survey was to make a detailed study of the farms and sites in three stages:-

(i) the stocking rates pre-spraying

(ii) the cost of chemical spraying and after-care

(iii) benefits from P. aquilinum removal

No set questionnaire was used. The information was obtained directly by interviewing the farmers in January 1976, repeating this in September 1978, and by viewing the Sites intermittently over the past four years.

Treatment at every site was made at 4 kg a.i./ha in 44 litres of water/ha, using the 40% w/v aqueous concentrate ('Asulox') containing the sodium salt of asulam. Helicopters fitted with standard aerial spraying nozzles were used. No surfactant was added.

RESULTS OF CASE STUDIES

Farm A

Farm A is a tenanted, Argyll hill farm near Oban, 280 ha in all. The ground rises from sea level to 200 m and rainfall is around 1800 mm per annum.

Four ha of the lower section of a hill were sprayed in 1973. This was an inbye gathering area and P. aquilinum was a particular nuisance as sheep and lambs got lost in it.

Follow-up treatment included liming and slagging but no fencing was done. Costs were as follows:

Spraying 4 ha at £32.50/ha	- £130
Liming 4 ha at 7.5 tonnes/ha at £33.75/ha	- £135
Slagging 4 ha at 1.26 tonnes/ha at £25/ha	- £100
Total cost	- £365
Gross cost per hectare	- £91.25
Less grant	- 50%
Net cost per hectare	- £45.63

The 4 ha can now be classed as improved inbye land and is constantly grazed carrying about thirty ewes. Previous to spraying the area was hardly grazed at all because of the density and height of P. aquilinum. So the farmer has virtually bought 4 new hectares for the cost of spraying, liming and slagging.

By 1978, 5 years after treatment, there was some P. aquilinum regrowth but the area is still grazing well. A further 6 ha was sprayed in 1976, then limed, slagged and part-reseeded, and in now contributing to the 15% increase in the farm's hill sheep flock since spraying commenced.

Farm B

Farm B, also in Argyllshire comprises 650 ha rising from sea level to 350 m. Rainfall is about 1780 mm per annum.

60 ha of P. aquilinum were sprayed and phosphated in 1974. 24 ha of this were actually limed and reseeded. The whole 60 ha were fenced.

Total gross cost was £9,000.

Less 50% grant

Net cost to farmer £4,500

Net cost per hectare £75

The farmer now has an improved upland pasture which can be used intensively in the spring for lambing, by the 400 ewes over an 8 week period in the autumn for tupping and over a 6 week winter period, and for controlled summer grazing with cattle.

It is difficult in isolation to put a monetary value on this, but better shepherding, use of quality tups, winter feeding of ewes, - lambing percentage at weaning rose from 55 to 75% and mean weight of speaned lambs increase from 27 to 32 kg - have all contributed to improved returns from the ewe flock and the farm as a whole, with no increase in farm labour.

Regrowth occurred on 20 ha by 1976 when re-spraying took place. This area was particularly difficult to treat because of the very steep and uneven terrain. An additional 32 ha was sprayed in 1976, and further areas of 16 ha in 1977 and 1978.

Farm C

Farm C is in Dumfriesshire. Rainfall in the area averages 1140 mm per annum and the hill area of the farm ranges in altitude from 200-400 m. Total area of the farm is 485 ha of which 365 ha are hill. 160 ha of the hill were previously P. aquilinum infested of which 120 were sprayed aerially in 1973. Except for two missed strips results were excellent and the farmer was very well pleased with the control. Follow-up treatment included a dressing with rock phosphate (Gafsa) at 0.75 tonne/ha over the sprayed area, together with cobalt at 2.24 kg/ha.

The whole 365 ha hill was subsequently fenced into six hill paddocks.

1973 costs were:

Cost of asulam and application	- £3,600
Cost of Phosphate and application (including cobalt £540)	- £4,815
Fencing cost for 365 ha	- £2,425
Gross cost	- £10.840
less 50% grant	- £5,420
Net cost	- £5,420

Taking one third of fencing costs for sprayed area, the cost, with the help of the grant, of releasing virtually 120 ha of extra improved hill land was about £4,610. At 1976 prices this at £38.43 per hectare was an excellent buy. Previous t spraying, stocking of hill was with 600 Blackface ewes crossed with Border Leiceste tup. Lambing percentage at that time was around 80% at marking.

If spraying had not been done, the stocking rate would need to have been reduce due to encroachment of P. aquilinum. Again with better management, and not solely due to the P. aquilinum control, lambing percentages have gone up to around 100%, a the ewe flock was being gradually increased to at least 650. Average returns from lambs in 1975 was £12/head.

Previous to P. aquilinum removal the farmer would not put cattle stock on the hill because of fear of poisoning. The main financial benefit immediately to the farmer was that in 1975 he had 30 summer-grazing cattle from a neighbouring farmer, on the hill, at £15/head. In 1976 this was increased to 100 head at the same income £15/head. So here was an extra annual return from the hill of £1,500 due solely to P. aquilinum removal. By 1978, although there was slight P. aquilinum regrowth on some parts of the hill, summer stocking was increased to 120 at £20/head.

Farm D

Farm D is a small 160 ha hill farm in Kircudbrightshire. The hill section, 120 ha, rises from 65 m to 200 m. Rainfall is around 1140 mm per annum.

The farmer has 120 ha hill

8 ha rough grazing

32 ha arable

His flock is 240 Blackface ewes crossed with Border Leicester tups. The farm also carries 60 suckler cows.

8 ha were sprayed in 1973 and 8 ha again in 1974 which cost £240 and £260 respectively.

At first visit the farmer felt he had, so far, received no real benefit from th spraying as the ewes had not grazed the sprayed area much at all the year after spraying. Not till two years after did they spend much time grazing it. Previous t spraying the P. aquilinum area was not grazed by the flock at all during summer but in autumn and winter when the P. aquilinum had died back they at least spent some ti on it. A further 8 ha of P. aquilinum infested land could be treated.

The farmer felt he has had no financial benefit from spraying, but looking at the returns from this farm one realizes that this is a very productive hill.

In 1975 his returns from sheep alone were:-

240 ewes produced 348 lambs sold at an average price of £13.50/head.

i.e. income from lambs	- £4,698
Wool clip off 300 head (including tups and gimmers)	- £ 275
Hill ewe subsidy 210 ewes only at £3 per head	- £ 630
Gross sheep income off hill	- £5,603

As 8 ha of hill land was still *P. aquilinum* infested and virtually non-productive and also the 8 ha sprayed in 1974 were not yet productive this gross income could be considered to come off a hill of 104 ha i.e. £53,27 income per ha. This is off a natural hill that has not been limed or slagged in the farmer's memory.

When the other 16 ha come into full production surely they should give the same income per ha provided the stocking rate is increased? This had not been increased by 1978, but the high productivity is being maintained and the lambs are expected to average £28/head.

Farm E

Farm E is in Cumbria and extends to 1,800 ha. The hill rises from 150 m to 900 m, *P. aquilinum* infested land is from 250 to 520. Rainfall is over 2300 mm per annum.

In 1975 there were 3,300 ewes comprising a mixed flock of Swaledales and Herdwicks, lambing at around 100%. Of the 3,300, 800 were hoggs and shearlings. About half of the 65 rams were North Country Cheviots for crossing. There were 40 suckler cows (spring calving), and calves kept to 18 months. Over 100 head of cattle were carried.

The first attempt at *P. aquilinum* control was on the lower ground in the 1950s with a Holt brackencrusher. During the summer months from June to September the crusher was used over 160 ha. The *P. aquilinum* stand was reduced from a height of 2 m to 0.6 m. This was done without grant aid. Rushes (*Juncus* spp), came in, however, after the partial control of the *P. aquilinum*. Lime and slagg were applied together with open ditch draining with a Foster digger. Lime has been applied 2 or 3 times over the years.

In the summer of 1974, 150 ha were sprayed by helicopter. The total cost of asulam plus application was £32/ha. Follow-up treatment was done in April 1975 and consisted of an aerial dressing at 0.25 tonne/ha of a high phosphate, low nitrogen fertilizer. This cost £100 per tonne and £14.80/ha to apply.

Cost of asulam and application	- £4,800
Cost of fertilizer	- £3,750
Application of fertilizer	- £2,200
Gross cost	- £10,770
Net cost (less 50% grant)	- £5,385 (£35.90/ha)

In July 1975 another 50 ha were sprayed and the same fertilizer follow-up treatment was applied in 1976. This was also grant aided.

With the control of the *P. aquilinum* the farmer planned to increase the sheep stocking rate. In 1975 125 extra ewes were carried, but no more cattle.

Interestingly, on the fertilized hill at over 300 m the hill cows were reluctant to leave the area in December 1975 when they were being taken off for the winter. In previous years hunger made them only too glad to come off.

Unfortunately regrowth of *P. aquilinum* from 1977 on the slopes beneath the trees where it was difficult to spray properly and on the hill-top has necessitated sheep stocking being reduced again to pre-spraying levels.

Farm F

Farm F is a small 60 ha hill farm also in Cumbria. The land rises from 180 - 300 m. Rainfall is on average 2000 mm per annum.

Area selected for spraying was a 20 ha hill bracken-covered to a height of 2 m and a great harbour for ticks. In one year alone 30 lambs were lost to tick-borne diseases.

Before spraying, stocking by cattle was for two months only during the year. The rest of the time it carried 30 ewes with single lambs.

In August 1972 the hill was aerially sprayed with asulam and was one of the first extensive hills treated. Because of this, the cost of spraying was kept low, as the contractor, wishing to prove the effectiveness of the work, only made a nominal charge for the application.

After-care treatment included liming, slagging, fertilizing and fencing. e.g.

	Gross cost	Net after 60% grant
Summer 1972 P. aquilinum spraying	£ 417	£ 167
Autumn 1972 lime and slag	£1,076	£ 430
1973 Fertilizer	£ 825	£ 330
1973 Fencing	£ 722	£ 289
1974 2nd Fertilizer	£ 460	£ 184
Total (for 20 ha)	£3,500	£1,400
Per ha	£ 175	£ 70

Results of the improvement were eradication of P. aquilinum; an improved grass/clover sward; greater stocking capacity; elimination of tick-borne disease; extra and healthier lambs. The land can now carry cattle summer and winter, supplemented in winter with hay, and carries an extra 20 ewes and 30 lambs during the summer. The lambs are so much heavier that the ewe lambs or gimmers can be tupped as hoggs in their first year. lambing at one year old instead of two. Income in 1973/74 due to the improvement is costed as follows:-

Saving in veterinary costs, £20 yearly	- £ 40
Net income from cattle, winter 1973	- £1,200
Net income from cattle, summer 1974	- £1,100
Value of extra lambs, 12 at £10	- £ 120
Added value of the other lambs 30 at £1	- £ 30
Total	- £2,490 = £62.25/ha/annum

The farmer made sure of no P. aquilinum regrowth. On three occasions in the summer of 1975, with four helpers, he spent half a day walking over the 20 hectares scything down every P. aquilinum frond that dared to raise its head. In 1978 the site is fully-productive as a dairy pasture, grazing 60 cows throught the summer.

DISCUSSION

The results achieved are undoubtedly biassed in the sense that the farmers concerned had already made a conscious decision that it would be economic to clear their land of P. aquilinum. They chose the land to clear, and except at Farm E and a section at Farm B all spraying was successful. Aerial spraying of open undulating terrain rather than very steep or tree-dotted slopes has given the best results.

Some form of after-care treatment was undertaken at five sites (Farms A, B, C, E. F). Reseeding, which was only partial, took place at just one site (Farm B), and was not more widely practiced because of inaccessibility and because indigenous swards based mainly on bents and fescues developed after P. aquilinum removal. The presence of an underlying sward was an important factor in site choice and farmers generally felt that money could be better spent on improvement by fertilizer rather than by reseeding. Indeed, phosphate was applied at five sites, and lime at three of these. It was decided to fence at two sites to give a better and healthier balance of summer grazing and to make new areas available as lambing or tupping parks.

Increased stocking in itself leads to increased expenditure on purchasing animals (or retaining those that could have been sold). If it is cattle the farmer is increasing, he may have to put up extra buildings for winter housing, and he will have to grow or buy extra winter-keep as well as perhaps concentrates.

The general message is that the success of P. aquilinum clearance schemes depends very much on the individual farm and on management policy. The only criticism we have of farmers is that they should perhaps spend more time ensuring that the spray contractor does a good job. We recognize that no two hill farms are exactly alike, but we hope that some useful patterns of treatment and costs have been recorded which others will be encouraged to follow, albeit with inevitable and necessary modification.

Only in areas under pressure such as the Lake District and Dartmoor are there environmental constraints on P. aquilinum spraying where the change in landscape use and landscape colour may be questioned. The only curb to treatment in Scotland occurs on farms in water catchment zones.

We feel that the control of P. aquilinum by spraying with asulam is amply justified in agricultural terms and that benefits to the hill farm economy should always accrue and develop as time goes on, particularly with a buoyant hill-farming industry.

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A CONSIDERATION OF THE CONTRIBUTION TO PRODUCTION OF *RUMEX OBTUSIFOLIUS* IN A GRAZING REGIME

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Summary In grassland grazed intensively by dairy cattle the % consumption of *Rumex obtusifolius* differed only slightly from the consumption of grass. On the basis of 27 samplings the mean % consumptions were:- grass 71%, dock 60%. The results for the % consumption of dock during the June/July period showed that this was best predicted on the basis of a positive correlation with grazing intensity and % stem in the dock. There was also a negative correlation with the digestibility of the dock material. The *in vitro* digestibility of dock was less than that of grass, 58% compared to 76%, and the mean DMD of the component parts, stem, leaf and petiole, from three of the sites were 56%, 63% and 68% respectively. An *in vivo* trial gave comparable results to those derived by the *in vitro* techniques.

Résumé Sur les herbages broutés intensivement par le bétail laitier, la consommation pour cent de *Rumex obtusifolius* n'a varié que légèrement de celle de l'herbe. Sur la base de 27 échantillons les consommations moyennes pour cent étaient pour l'herbe 71%, pour le *Rumex obtusifolius* 60%. Les résultats de la consommation pour cent de *Rumex obtusifolius* pendant la période juin-juillet ont démontré que la meilleure base sur laquelle on pouvait prévoir ceci était une corrélation positive avec l'intensité du pâturage et le pourcentage que représente la tige dans le *Rumex obtusifolius*. Il y avait aussi une corrélation négative avec la coction de matière de *Rumex obtusifolius*. La coction *in vitro* de *Rumex obtusifolius* était moins que celle de l'herbe, 58% par rapport à 76%. Le DMD moyen des parties constituantes, la tige, la feuille et le pétiole de trois des terrains étaient respectivement 56%, 63% et 68%. Un essai *in vivo* a donné des résultats comparables avec ceux obtenus au moyen de techniques *in vitro*.

INTRODUCTION

The order of contribution which *Rumex* spp. can exhibit annually as a conservation system has been reported as 1.9 t/ha of d.m. (Savory and Soper 1973) and as between 1.0-3.0 t/ha (Courtney 1972). Conserved in silage it is probable that, with the exception of hard stems, dock material is readily accepted by the ruminant.

In the grazing situation, however, some selective intake might be expected. Ormroyd (1966) and Harkness (1976) suggest that *Rumex* spp. in pasture are largely avoided by the grazing animal. The data presented in this paper represent an attempt to establish the extent to which selective grazing by dairy cattle occurs in relation to docks. In addition consideration is given to the digestibility of dock material and the extent to which this may influence nutritional value.

METHODS AND MATERIAL

Sites

A single site was examined in 1974 and this was supplemented by data from a wider range of situations in 1978. The 1978 survey was confined to dairy herds in an area convenient to the station headquarters, ie, North Down and South Antrim. The farms were selected by recommendations of local advisory staff as having a range of dock infestation levels and regular grazing systems. In all 19 fields on 9 farms were sampled, 8 of these fields on two occassions (Table 2).

So that growth during the sampling period could, for all practical purposes, be neglected, areas were chosen where the grazing period was expected to be of short duration and involved fields, paddocks, and strips where an electric fence was being used. The grazing periods ranged from 12-60 h; in only one instance (field 23) was this exceeded.

Dry matter consumption

The extent to which docks were being eaten by the grazing animal was estimated using a sequence of pre and post grazing clips. Ten sample cuts, each 0.904 m x 6.0 m, were normally taken on each area at each sampling date, immediately prior to and immediately subsequent to grazing.

The cut material was separated in the field into dock and grass and fresh weights determined.

Grass dry matter determination and botanical composition

A 200 g sample of grass was taken for d.m. and *in vitro* digestibility determination together with a further 50-100 g sample for botanical composition.

Dry matter determination of *Rumex* component parts

In the samples taken early in the year (period A:- 24/5-30/5) no separation into component parts was made. In the 18 samples taken later (period B:- 23/6-14/7) where inflorescence formation had commenced, the d.m. yield of (a) stem, including inflorescence (b) petiole, and (c) leaf was assessed separately. In the majority of cases all the dock material was separated and d.m. yields recorded but where a large amount of material was present a 200 g sub-sample was used.

In vitro digestibility

The *in vitro* digestibility of both grass and *Rumex* was assessed from a single bulked sample taken from each site at each sampling date from the pre-grazing cut and separated into dock and grass fractions. The method adopted was that of Tilley and Terry (1963). Data for the various component parts of the dock plants were obtained from the three fields - 10, 19 and 20.

In vivo digestibility

A small *in vivo* trial with sheep was conducted so that a comparison could be made with the *in vitro* determinations. The comparison made was between grass alone and a grass-dock mixture, 3.5-4.0 kg being fed per sheep per day. The grass and dock samples were harvested separately on 20.6.74. The grass-dock mixture was made up by using 2 parts of grass to 1 part of dock by weight. The pure grass and the mixture were stored in a deep-freeze and later (March 1975) fed to the sheep. The method was that normally adopted in assessing the apparent digestibility of roughages by sheep.

Table 2

Basic data from the sites sampled

Sample No. & Date	Grazing Intensity Cow Days/ha	% Dock	DM Yield t/ha Grass	DM Yield t/ha Dock	% Consumption Grass	% Consumption Dock	% Digestibility Grass	% Digestibility Dock
A. Early (24/5-30/5)								
1	63.0	5.5	0.93	0.054	91.1	80.9	78.0	53.3
2	79.1	0.7	1.74	0.012	82.8	86.2	79.2	61.5
3	81.5	2.6	0.88	0.024	88.5	20.2	74.1	60.0
4	90.6	0.9	1.09	0.010	80.5	42.8	69.4	55.9
5	121.4	3.5	0.85	0.031	47.7	53.1	76.8	55.3
6	126.0	1.2	1.44	0.018	61.0	62.1	75.9	52.3
7	148.3	1.5	1.95	0.030	88.6	88.1	79.2	60.6
8	192.3	3.9	1.64	0.066	74.7	21.7	77.7	60.9
9	197.7	23.3	0.13	0.038	51.9	74.1	78.5	63.8
MEAN A.	122.2	4.8	1.18	0.031	74.1	58.8	76.5	58.2
B. Mid-Season (23/6-14/7)								
10	49.4	5.2	0.96	0.053	63.2	73.1	78.0	58.2
11 (3)	54.4	2.4	0.44	0.011	42.4	32.4	74.3	60.0
12 (1)	63.0	15.0	0.82	0.144	95.8	79.2	78.4	45.8
13 (2)	79.1	1.6	0.48	0.008	73.2	2.7	78.0	64.9
14 (4)	90.6	0.5	0.87	0.005	82.5	68.0	70.1	57.1
15	98.8	0.9	0.32	0.003	30.5	2.9	71.6	68.5
16	98.8	4.6	0.33	0.016	71.2	34.9	67.6	60.7
17	108.7	1.5	0.49	0.007	59.7	68.8	65.9	55.1
18	111.2	3.4	1.39	0.050	72.2	85.8	80.0	61.1
19	123.6	4.5	0.78	0.037	82.1	71.7	76.9	62.5
20	123.6	2.0	1.01	0.021	78.6	84.6	74.3	60.3
21 (6)	126.0	0.5	2.59	0.014	69.0	58.0	77.1	58.8
22	148.3	3.2	1.38	0.045	71.8	42.5	73.1	55.9
23	148.3	0.7	1.43	0.011	72.2	91.4	74.1	47.1
24 (7)	165.6	4.8	1.74	0.088	74.8	83.3	77.1	55.7
25 (8)	192.3	10.2	1.36	0.155	56.6	73.1	72.5	52.1
26 (9)	197.7	28.0	0.63	0.244	68.6	63.5	75.7	64.6
27	222.4	11.2	1.66	0.209	71.5	78.2	74.1	53.9
MEAN B.	122.3	5.6	1.04	0.061	68.7	60.8	74.4	57.9
MEAN A. & B.	122.25	5.2	1.11	0.046	71.4	59.8	75.5	58.1

( ) Sample No. if sampled early. A.

The animals, in duplicate, were housed in metabolism crates which allowed the controlled feeding of the test feeds and the separate collection of discards, dung and urine. There was a preliminary 10-day period of feeding followed by a 7-day test period.

RESULTS

Dock consumption

In 1974, supplementary to a study on the control of R. obtusifolius in conservation systems, pre and post grazing clips were taken from two grazing paddocks on 4 occasions during the period June-October and the % consumption of grass and docks recorded (Table 1). Grazing intensity was high with 1.5 acres being grazed by 70 dairy cows in a single day.

Table 1

Dock consumption, throughout the year in a paddock system

Date	Paddock	% dock in sward	% Consumption Grass	% Consumption Dock
27/6	1	2.1	92	78
27/7	1	4.2	55	70
*3/9	2	5.6	71	70
*3/10	2	4.6	80	96

*due to change in utilisation of paddock 1, by young stock an adjacent paddock 2, was sampled.

Consumption of docks was much higher than anticipated. Throughout a large part of the year there was no evidence of the selective rejection of Rumex in the sward; indeed on occasion the % consumption of dock was higher than that of grass.

The data for 1978 allow a much more detailed and extensive analysis of the consumption of docks by the grazing animal to be made.

On the basis of % docks in the pre and post grazing clips the % intake of dock, meaned over the 27 assessments (Table 2) was only 12% less than that of grass - 59.8% compared to 71.4%. In order to establish which factors influenced the intake of docks by dairy cattle the data were subjected to a number of tests for the correlation of % dock consumption to individual factors such as grazing intensity and % of dock in the sward (Table 3).

Although these correlations were assessed initially on all the data, the results presented have been derived from those 18 situations sampled between mid June and mid July when a separation of the dock into stem, leaf and petiole was possible.

Although none of the coefficients are of a high order significant positive correlations were found between % dock consumed and with both the proportion of grass consumed and % stem in the dock material. Surprisingly also there was a strong negative correlation with the digestible dry matter percentage of docks.

Table 3

Correlation tests of % dock consumption with biological and management factors

Factors	Correlation Coefficient r	Significance
% Grass Consumed (%GC)	0.5316	*
% Dock in the pasture (%DP)	0.2976	NS
Dock Digestibility %(DD%)	-0.5707	*
Grass Digestibility %(GD%)	0.280	NS
% Stem in the dock %(SD)	0.5269	*
Grazing Intensity cow days/ha (CDH)	0.3951	NS
Total d.m. intake per cow per day	0.4198	NS

In addition multiple regression coefficients for the combined effects of these individual factors were calculated and their statistical significance tested. From the computer programme adopted the combination of variables giving the best fit to the data was defined and the appropriate equation to relate these factors to % dock consumption calculated.

The consumption of dock could be predicted most effectively (P >0.001) on the basis of a multiple regression formula, which introduced grazing intensity, dock digestibility and the % of stem in the dock.

$$\% \text{ Dock Consumption} = 43.6 + 0.814\ (CDH) - 1.58\ (DD\%) + 2.64\ (\%SD) - 0.0175\ (CHD)\ (\%SD)$$

$R = 0.802$ $R^2 = 0.64$ Significance***

These same three components predicted the consumption of the component parts of the dock, ie stem, leaf and petiole with equivalent levels of confidence. In general the % consumption of dock stem was less than that of either leaf or petiole. This applied to 15 of the 18 samples involved.

Digestibility - *In Vitro*

Table 4

% Digestibility *in vitro* of *Rumex* vegetative parts

Field	Stem	Leaf	Petiole
10	54.5	64.4	71.1
19	55.7	63.5	63.7
20	58.3	61.7	69.7
Mean	56.1	63.2	68.2

The digestible dry matter percentages are presented in Table 2 averaging 75.5% for grass and 58.1% for docks. In addition the digestibility of the main dock components, leaf, petiole and stem, from 3 fields is shown in Table 4. These data confirm the relative digestibility of these parts determined at an earlier date

(October 1972). In that case the % digestibilities were - green leaf 53%, petiole 72% (dead leaf 32%, dead petiole 53%), main spike of the inflorescence 37.1%, axilliary spikes 44%, and floral parts stripped off the inflorescence 33%. In both instances petiole appears to be the most and stem the least digestible part of the plant.

Digestibility - In vivo

Table 5

A comparison of in vitro and in vivo digestibility tests

Technique	Test material: Grass alone	Grass + Dock	Dock	Dock/Grass %
in vivo	75.8	71.6	63.2	83.4
in vitro	69.0	-	57.8	83.7

The in vivo digestibility trial on Rumex gave comparable results to the data derived by in vitro digestibiltiy techniques. The mean in vivo digestibility of grass alone was 75.8% and of the grass-dock mixture 71.6%. From this it may be calculated that the digestion of dock material was 63.2%. The in vitro digestibility of this same material, oven dried and tested at the time of harvest, was somewhat lower - grass 69.0%, dock 57.8% - but showed the same relative values, with the Rumex digestibility some 83% of that of the grass (Table 5).

DISCUSSION

The data presented illustrate both the consumption and digestibility of Rumex obtusifolius in pastures intensively grazed by dairy herds in N. Ireland. Although the records have been restricted for practical reasons to a limited number of herds and fields, they do indicate a surprisingly high intake of dock material. This confirms data previously gathered. In the majority of cases the % consumption of Rumex was nearly equal to that of grass and there was little evidence of the selective grazing that had been expected. The data are interesting in that they in fact suggest that dock consumption increased as stem content increased and also that dock consumption increased at the lower dock digestibility percentages. These two factors are likely to be related, % digestibility tending to decline as stem content increases.

The reason for this result is not easy to explain. The pastures involved were considered to be high grade ryegrass pastures (perennial ryegrass contents of all but two exceeding 50% with many over 75%) and were being grazed at a highly nutritious stage (in vitro digestibility over 70% in all but three cases). Perhaps the ruminant is seeking less digestible material to counter some imbalance in the diet or it may be that the increased consumption is influenced by the more erect habit of dock growth and its presentation in the sward.

The digestibility data, either in vitro or in vivo, show the dock to have a digestibility only about 80% of that of grass. On average if, as in this case, the consumption is only 85% and digestibility 80% relative to grass, then dock d.m. yields may be said to be only 65% as valuable as associated grass material. They do however on occassion make a considerable contribution to d.m. yields in a pasture. This however omits any consideration of the full nutritive value of dock d.m., stated by Fairbairn and Thomas (1959) to be high, which would further influence any such attempted equation. There is one final factor which Fairbairn and Thomas (1959) suggest may influence the feeding value of the dock material. This is the presence of oxalic acid. The current investigation has not included any assay for this chemical although it is reported in other Rumex spp. as being potentially toxic.

In view of the somewhat surprising relationships indicated between dock consumption and stem content and digestibility it would be premature to draw firm conclusions at this stage. These results indicate that the role of docks in a grassland sward and their contribution to yield under a grazing regime is not a simple one and that the situation merits some further experimental investigation.

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THE REPLACEMENT OF OLD SWARDS USING HERBICIDES AND CULTIVATION TECHNIQUES

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Summary Paraquat and glyphosate were compared for sward desiccation prior to direct drilling or rotovation and drilling of grass seed at six sites in Wales. Paraquat gave quick desiccation but regrowth of some grass species and perennial broad leaved weeds occurred. Glyphosate was slower in action but gave an improved kill of the old sward, particularly of *Rumex* sp.

Rotovation and drilling of the seed gave a good establishment of grass at all sites; there was only a small advantage with the use of a sward desiccant. Direct drilling gave a poor initial establishment at all sites and only produced a satisfactory sward at half of the sites. Glyphosate at 1.8 kg a.i./ha gave the best establishment of sown species but was only slightly superior to the lower rate of glyphosate and paraquat. Factors related to the poorer performance of direct drilling are discussed.

INTRODUCTION

There has been an increasing trend in Wales to reseed grassland in the late summer to minimise the loss of production and to ensure a satisfactory establishment of the reseed. There is need for information on techniques which could speed up the transition from the old to the new sward.

Paraquat is recommended for sward desiccation prior to direct drilling of grass under certain conditions (ICI Plant Protection 1976). Experimental work has indicated it to be advantageous where minimal cultivations were used (Douglas 1965). Glyphosate has been shown to control a wide spectrum of perennial weeds (Davidson 1972). Rowlands (1976) found some advantages for glyphosate compared to paraquat for sward desiccation prior to the direct drilling of fodder crops. The effectiveness of glyphosate appears to be greatest in late summer (Oswald 1976). Douglas (1965) found that some form of cultivation was necessary to obtain satisfactory establishment of grass following paraquat application and that rotary cultivation produced the most consistent results. There has been insufficient experimental work on the direct drilling of grass to draw any general conclusions as to its effectiveness (Davies and Cannell 1975).

It was decided, therefore, to carry out a series of trials on commercial farms to compare paraquat and glyphosate for sward desiccation prior to grass seeding using a rotovator plus seed drill or a direct drill.

Table 1

Site Details

Site reference Location	A Bassaleg Gwent	B Trawsgoed Dyfed	C Anglesey Gwynedd	D Pwllpeiran Dyfed	E Gelli Aur Dyfed	F Pencoed Mid Glamorgan
Sward Type	Long term grass	Long term grass	Long term grass	Long term grass	Permanent pasture	Permanent pasture
Pre Spray Use	Grazing	Grazing	Grazing	Silage	Grazing	Grazing
Main Sward Components %	*Lolium perenne* 42 *Agrostis sp* 20	*Dactylis glomerata* 42 *Bromus mollis* 7 *Agrostis sp* 24	*Agrostis sp* 52 *Dactylis glomerata* 24 *Festuca arundinacea* 15	*Lolium perenne* 48 *Agrostis sp* 21	*Lolium perenne* 37 *Holcus lanatus* 16 *Agrostis sp* 12 *Dactylis glomerata* 11	*Holcus lanatus* 39 *Agrostis tenuis* 29
Lolium perenne %	42	9	3	48	37	10
Broad Leaved Weed %	12	8	2	3	15	2
Spraying Date	2/9/75	17/8/75	28/8/76	16/8/76	27/7/77	26/7/77
Direct Drill Type	i) Rotoseeder ii) Bettinson (one pass)	Rotoseeder (one pass)	Moore Uni-drill	Rotoseeder	Moore Uni-drill	Rotoseeder
Row Width	i) 17.8 cm ii) 12.7 cm	12.7 cm	12.0 cm	12.7 cm	12.0 cm	12.7 cm
Soil Texture	Silty loam	Silty loam	Silty loam	Silty loam	Silty loam	Silty loam

All sites except A and B cross drilled

METHODS AND MATERIALS

Six experiments were carried out between 1975 and 1977 at sites throughout Wales. Site details including previous management and sward composition are given in Table 1.

Swards were allowed to regrow following cutting or grazing so that there was 5-12 cm of leaf present when the following herbicide treatments were applied:-

1. Glyphosate 0.9 kg a.i./ha
2. Glyphosate 1.8 kg a.i./ha
3. Paraquat 1.1 kg a.i./ha
4. No chemical

The chemicals were applied in 450 l/ha water at a pressure of 2 bars using an Oxford Precision sprayer with plots of 3.7 m x 11 m. Dates of herbicide application are given in Table 1.

The following reseeding treatments were carried out approximately 14 days after herbicide application.

1. Direct drill
2. Shallow rotovation

At sites A, B, E and F, plots of the old sward were left and subjected to the same husbandry as the reseeded plots. The no-chemical treatments were topped prior to reseeding. The seeds mixture sown was based on *Lolium perenne* and *Trifolium repens* and was sown at 33.6 kg/ha. Direct drilling was carried out by a range of drill types, details are given in Table 1; at all sites except A and B cross drilling was employed. Shallow rotovation consisted of one or two passes of a rotovator followed by cross drilling of the seed with an Oyjord drill, row width 12.7 cm. All trials were rolled after drilling and adequate fertiliser was applied.

All sites A and B reseeding treatments were applied in bands across the herbicide treatments, these trials had two replicates of herbicide treatments and three replicates of reseeding treatments. A split plot design was used for the remainder of the trials with two replicates at sites C & D and three replicates at sites E and F.

RESULTS

Table 2

Percentage Sward Desiccation at Drilling

Glyphosate	0.9 kg a.i./ha	77.8
Glyphosate	1.8 kg a.i./ha	89.0
Paraquat	1.1 kg a.i./ha	85.5
No herbicide		0.0

An eye estimation of the percentage of the sward desiccated was made 14 days after spraying, the results are given in Table 2.

Paraquat gave a quicker sward desiccation reaching over 95% at peak but when cultivations and drilling were carried out, 14 days after spraying, some regrowth of the old sward had occurred. Regrowth of Dactylis glomerata and perennial broad leaved weeds especially Rumex sp was considerable. Glyphosate gave a slower kill which continued after drilling where soil disturbance was minimal, the final level of desiccation was slightly greater at the higher application rate; this effect was most noticeable under adverse weather conditions such as the dry conditions of 1976.

The initial establishment on the sown species was recorded using a 0-9 scoring system, the results are given in Table 3.

Table 3

Initial Establishment of sown seed 0 = nil 9 = Full Establishment

		Direct Drill	Shallow Rotovation
Glyphosate	0.9 kg a.i./ha	4.8	7.4
Glyphosate	1.8 kg a.i./ha	5.2	7.4
Paraquat	1.1 kg a.i./ha	4.4	7.4
No herbicide		2.2	7.0

It shows that a good establishment of seed followed shallow rotovation with little difference between the herbicide treatments. Initial establishment after direct drilling was inferior at all sites; the use of a herbicide improved establishment, there was a small advantage from glyphosate compared to paraquat.

After direct drilling at site B there was considerable germination of Bromus mollis seed which competed strongly with the sown seed. As only one pass of the direct drill has been used the Bromus mollis seedlings had considerable bare ground in which to establish, as a result of this problem cross drilling was employed in all later trials.

At site F frit fly was detected on grass seedlings, the incidence was much more severe on the direct drilled areas. Chlorpyrifos was applied to control the pest, but by this time it had caused considerable damage.

Approximately nine months after sowing a sward analysis was carried out using the point quadrat method.

Table 4

Percentage of sown species (Lolium perenne and Trifolium repens) nine months after sowing

		Direct Drilled	Shallow Rotovation
Glyphosate	0.9 kg a.i./ha	49.7	67.2
Glyphosate	1.8 kg a.i./ha	54.0	66.6
Paraquat	1.1 kg a.i./ha	48.1	65.3
No herbicide		31.9	62.2
Original sward		29.1	

Details of the sown species content of the sward are shown in Table 4. It indicates that at all sites shallow rotovation resulted in a sward with a high content of sown species. The use of a sward desiccant gave only a small increase in sown species and there was little difference between herbicide treatments. Direct drilling into the old sward gave no increase in its *Lolium perenne* and *Trifolium repens* content; this effect was consistent at all sites. Sward desiccation improved the effectiveness of direct drilling, but the sward produced contained a lower percentage of sown species than that produced by shallow rotovation. However, there was considerable variation between sites; at site E direct drilling gave the best result while at sites A and C it gave acceptable results, within 8% of shallow rotovation, but at the remaining sites it was inferior to rotovation. Glyphosate at 1.8 kg a.i./ha tended to produce swards with the highest content of sown species but the differences between herbicide treatments were small.

The effect of the treatments on the broad leaved weed content of the sward is shown in Table 5.

Table 5

Percentage of broad leaved weeds nine months after sowing

		Direct Drill	Shallow Rotovation
Glyphosate	0.9 kg a.i./ha	7.8	10.4
Glyphosate	1.8 kg a.i./ha	8.3	8.5
Paraquat	1.1 kg a.i./ha	9.6	11.7
No herbicide		2.8	10.4
Original sward		5.1	

The main broad leaved weeds present in early summer were *Stellaria media*, *Ranunculus repens*, *Taraxacum officinale* and *Rumex* sp.

The increase in the broad leaved weed content of the sward over the level in the original sward was due to the germination of weed seeds.

Shallow rotovation stimulated the germination of more broad leaved weed seeds than direct drilling, many of them were annuals which had mostly disappeared by the time sward assessments were made. The effectiveness of the sward desiccation treatments on perennial broad leaved weeds were confounded by the presence of seedlings but can be seen better with reference to detailed counts of *Rumex* sp which were made at site E and are given in Table 6.

Table 6

Numbers of Rumex sp 000/ha nine months after sowing at site E

		Direct Drill	Shallow Rotovation
Glyphosate	0.9 kg a.i./ha	2.3	16.8
Glyphosate	1.8 kg a.i./ha	2.5	30.9
Paraquat	1.1 kg a.i./ha	13.7	23.3
No herbicide		9.3	19.3
Old sward		5.6	

The increase in Rumex sp numbers over the number present in the original sward was due to the germination of seed. This was considerable and variable after shallow rotovation and confounded any herbicide effect.

After direct drilling the majority were mature plants and herbicide effects were evident. Glyphosate at both rates gave good control of Rumex sp but paraquat by removing grass competition enhanced their growth.

The only direct comparison between drill types was made at site A where the Rotoseeder was superior to the Bettinson due to penetration problems with the latter and also to its wider row width. Other comparisons can only be made between sites and therefore are subject to site and other factors. The initial establishment of grass and clover produced by all drill types was poor but the Rotoseeder tended to give the best results. At 50% of the sites both the Rotoseeder and the Moore Uni-Drill produced swards containing a sown species content within 10% of the shallow rotovation treatment.

DISCUSSION

The trials reported have shown some advantage for glyphosate compared to paraquat, particularly for the control of Rumex sp, where direct drilling is to be carried out two weeks from spraying. To utilise the improved efficiency of glyphosate the direct drilling technique must ensure a good establishment of sown species. The results presented show that all the direct drills used gave poor initial establishment of grass and clover. However at half the sites the environment enabled the development of a sward containing over 60% sown species. Squires & Elliott (1972) showed that the presence of surface trash reduced the establishment of Lolium multiflorum. The desiccation of an old grass sward results in considerable surface trash which must have been partly responsible for the poor initial establishment of sown seed. Soil pests such as frit fly suffer minimal disturbance from direct drilling and remain in an ideal position to migrate and attack the emerging seedlings. A serious frit fly attack was reported at site F; this and other soil pests could have been present at a lower level on other sites. Shallow rotovation has performed consistently in these trials while the benefits of sward desiccation were small; this is at some variance with the results of Douglas (1965). Additionally the technique did result initially in a higher broad leaved weed population.

Late summer desiccation of an old grass sward followed by the direct drilling of a Lolium perenne Trifolium repens based seeds mixture can be successful but presents a higher risk factor than conventional methods, including shallow rotovation.

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