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A PRELIMINARY EXAMINATION OF THE DIFFERENTIAL REACTION OF PERENNIAL AND ITALIAN RYEGRASS CULTIVARS TO GRASS-KILLING HERBICIDES

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Summary Differential susceptibility of cultivars to herbicide was found when grass-killing herbicides were applied logarithmically to ten Lolium perenne and five Lolium multiflorum cultivars sown in drills. The herbicides used were Dalapon, Simazine, Atrazine, Paraquat, Aminotriazole, Asulam and Fluometuron. Regression analysis techniques showed that there was a linear relationship between a cultivar response metameter and the logarithm of herbicide concentration, and that regression lines for all cultivars with respect to any herbicide were parallel.

The dangers of using certain herbicides to control weeds in spaced plant nurseries involving different cultivars are noted and it is suggested that relative susceptibilities, calculated consequent on parallelism, could be a useful adjunct to established methods of cultivar classification and identification.

INTRODUCTION

The differential susceptibility of grass species to chemical herbicides has been clearly established (Thompson 1959; Charles and Lewis 1962; Vengris 1965). As a result, experiments on a wide range of grass species have been carried out in different parts of the world with a view to killing annual or perennial weed grasses in seedling or established swards of turf and forage species (e.g. Squires 1963; Peters 1964). Much of the work up to 1964 on selective control of grass in permanent pasture has been reviewed by Elliott and Allen (1964). Frequently research has been associated with eliminating undesirable grasses from stands to be used for seed production (Lee 1964; Ziegenbein 1964; Warren 1965).

However, although particular varieties of any grass which may have been involved in herbicide studies may have been named (Arthur and Shildrick 1964; Gournay 1965), few direct references have been made to differential susceptibility of cultivars within a grass species.

Using low doses of dalapon, Wallis (1962) found a glabrous form of Pennisetum purpureum to be more susceptible than the normal hairy type. Considerable differences in the response of two cultivars of Agrostis palustris to siduron were reported by Splittstoesser and Hopen (1967), and Alley et al. (1966) record differential tolerance of bromegrass varieties to Tordon 22-K. Previous work at Loughgall (Wright 1966) has suggested that there are differences between ryegrass clones with regard to their tolerance to certain grass-killing herbicides, one clone of S24 origin being apparently resistant to diquat, simazine and dalapon.

In the search for other resistant clones of diverse genetical origin ten cultivars of perennial ryegrass (Lolium perenne) and five of Italian ryegrass (Lolium multiflorum) were sprayed logarithmically with seven grass-killing herbicides. The randomised block lay-out allowed the relative reaction of the cultivars to the herbicides to be examined.

METHOD AND MATERIALS

The perennial ryegrass cultivars sampled the total range of ear emergence from very early to late, as follows:

Early emerging - Stormont Zephyr (U.K.); S.24 (U.K.); Presto (Denmark); Oriel (Rep. Ireland).

Medium emerging - R.v.P. Early (Belgium); S.321 (U.K.); Kent Indigenous (U.K.).

Late emerging - R.v.P. Late (Belgium); S.23 (U.K.); Sceempter (Netherlands).

The five Italian ryegrass cultivars included were EF 486 and Leda Daehnfeldt (Denmark), S22 and Stormont Ibex (U.K.) and R.v.P. (Belgium). Two replicates of each cultivar were sown in drills $1\frac{1}{2}$ ft apart on 29th April 1968 at a rate calculated to give twelve seedlings per foot of drill. Counts following seedling emergence confirmed the general uniformity of establishment, only Kent Indigenous having slightly more plants per unit length of drill than the average. The Presto rows were uneven and this cultivar had to be neglected in four of the seven trials in which it was included.

Seven weeks after sowing, the drills were sprayed logarithmically with seven herbicides, using a modified Oxford Precision sprayer. The peak doses (100% concentration), which were selected to anticipate complete kill, were as follows (a.i. lb/ac):- Dalapon 16; Simazine 8; Atrazine 8; Paraquat 1; Aminotriazole 8; Asulam 4; Fluometuron 2.

Concentration was reduced by 50% each 4 ft $7\frac{1}{2}$ in. of drill and, eight weeks after spraying, yield of green matter was recorded per 4 ft $7\frac{1}{2}$ in. section of drill, cutting being at ground level. An unsprayed portion of drill was also cut and weighed as a control. The average concentration applied to each section was a geometric mean, and the five recorded sections were designated as follows: 100 - 50% = 70.7%; 50 - 25% = 35.4%; 25 - $12\frac{1}{2}$% = 17.7%; $12\frac{1}{2}$ - $6\frac{1}{4}$% = 8.8% and $6\frac{1}{4}$ - $3\frac{1}{8}$% = 4.4%.

As the yields of the cultivars were inherently different the responses of each strain to the herbicide concentrations were expressed as the yield of each section divided by the control (no herbicide) yield for that cultivar and an analysis of variance carried out. Regression analysis techniques were then employed to determine the relationship between these response ratios and herbicide concentration.

By examining the regression equations, using a pooled regression coeff, it was possible to form an estimate of the effects of the herbicides on cultivars. If concentration C_t on the test cultivar gives the same response as a concentration C_s on a standard cultivar then the ratio C_s/C_t can be termed the susceptibility of the test cultivar relative to the standard. These relative susceptibilities were calculated using statistical analysis as employed in parallel line assay work (Finney 1964).

RESULTS AND DISCUSSION

From visual observation it was apparent that the species Lolium perenne and Lolium multiflorum responded differently to certain herbicides, perennial ryegrass being apparently more resistant to paraquat and more susceptible to Aminotriazole than Italian ryegrass. Differential intra-species tolerance to certain herbicides was also obvious. The reaction of the perennial ryegrass cultivars to Dalapon will be given as an example and digressions from this general pattern will be discussed.

Table 1.

Green matter yield in g of 10 perennial ryegrass strains at 5 concentrations of Dalapon

Mean Conc (%) / Cultivar	70.7	35.4	17.7	8.8	4.4	Unsprayed Control
Sceempter	10.3	28.7	73.9	145.8	227.4	260.3
S.23	0.8	5.6	14.3	57.6	89.5	239.8
R.v.P. Late	3.5	26.6	30.7	82.5	119.4	256.1
Kent	2.9	11.6	26.1	70.5	123.2	155.0
S.321	28.5	73.8	78.3	141.2	171.3	270.9
R.v.P. Early	2.8	6.8	33.9	91.6	152.7	255.0
Oriel	3.4	6.5	20.3	66.7	145.5	256.9
Presto	10.0	22.8	38.0	72.2	120.3	207.2
S. Zephyr	5.4	15.4	46.9	84.1	107.3	270.3
S.24	1.1	2.6	18.8	60.6	122.8	198.2
Total	69.0	200.5	381.4	873.0	1379.6	2370.0

The mean green matter yields of the ten perennial ryegrass cultivars for each concentration of Dalapon are given in Table 1 and the response ratios in Table 2. From an agricultural standpoint Table 1 shows in terms of actual yield the differential effect of cultivar to herbicide concentration. For example S.321 at the 70.7% concentration retains more herbage than Kent at the 17.7% concentration or when the three cultivars, R.v.P. Late, R.v.P. Early and Oriel which have virtually equal control yields, are sprayed with the 17.7% concentration R.v.P. Early has twice the production of Oriel, with R.v.P. Late intermediate in yield.

Table 2.

Response of cultivars calculated as ratio of section yield to control yield

Mean Conc (%) / Cultivar	70.7	35.4	17.7	8.8	4.4	Mean
Sceempter	0.04	0.11	0.30	0.57	0.90	0.384
S.23	0.00	0.03	0.06	0.26	0.39	0.149
R.v.P. Late	0.02	0.10	0.12	0.32	0.45	0.203
Kent	0.02	0.08	0.17	0.45	0.78	0.298
S.321	0.11	0.28	0.30	0.54	0.64	0.374
R.v.P. Early	0.01	0.03	0.13	0.36	0.60	0.226
Oriel	0.01	0.03	0.08	0.27	0.56	0.190
Presto	0.05	0.11	0.19	0.35	0.60	0.260
S. Zephyr	0.02	0.06	0.17	0.31	0.40	0.191
S.24	0.01	0.01	0.09	0.30	0.66	0.213

On analysis of variance of the response ratios in Table 2 it was found that strains and concentrations had both highly significant variation, although concentration as might be expected took up by far the major share of the variation.

However, it was extremely interesting to note that, for the concentrations studied, no interaction between concentration and strain existed i.e. the cultivar differentials were unaffected by herbicide concentration.

By regression analysis it was found that not only was the relationship between response ratios and logarithm of weedkiller concentration a linear one ($P < 0.001$, $F_{1,49} = 315$) but that the regression lines were almost parallel and that no further variation was left unexplained i.e. a linear relationship was the best fit and regression lines could be considered parallel.

Table 3.

Regression coeff and susceptibilities relative to S.24.

Cultivar	Regression Coeff	Susceptibilities Estimate	5% Lower Limit	5% Upper Limit
Sceempter	-0.7199	0.4358	0.2506	0.7417
S.23	-0.3356	1.3665	0.8276	2.2745
R.v.P. Late	-0.3627	1.0519	0.6389	1.7342
Kent	-0.6266	0.6613	0.3949	1.0956
S.321	-0.4393	0.4563	0.2637	0.7736
R.v.P. Early	-0.5005	0.9421	0.5713	1.5510
Oriel	-0.4433	1.1179	0.6791	1.8457
Presto	-0.4429	0.7975	0.4811	1.3142
S. Zephyr	-0.3332	1.1156	0.6777	1.8417
S.24	-0.5273	1.0000		

Regression coeff and relative susceptibilities (using S.24 as a standard with a susceptibility of unity) for the 10 cultivars are given in Table 3. Lower relative susceptibilities indicate tolerance and higher figures greater susceptibility to Dalapon. Sceempter Pasture and S.321 show most tolerance and S.23 and Oriel least.

There did not appear to be any pattern of reaction depending on whether or not a cultivar belonged to the early or late emerging group. This is perhaps to be expected as the herbicides were applied when the grass was in an immature non-reproductive stage.

Differential cultivar reaction to all the herbicides used was proven for perennial ryegrass but only for some herbicides in the case of Italian ryegrass. Table 4 shows the level of significance of the Variance Ratio test on differences between cultivars for each of seven herbicides. No results for reaction of Italian ryegrass to Aminotriazole were obtained due to sowing irregularities.

Table 4.

Level of significance of Variance Ratio test on differences between cultivars for each of seven herbicides

NS = not significant at 5% level * < 5% ** < 1% *** < 0.1%

	Dalapon	Simazine	Atrazine	Paraquat	Aminotriazole	Asulam	Fluometuron
Perennial	***	***	*	***	**	**	*
Italian	NS	**	NS	NS	-	NS	***

Although in seven cases differences were significant at the p = 1% level in four cases no differential cultivar reaction was detectable.

In all cases regression of response ratios on logarithm concentration was highly significant and in no case was there an interaction between cultivar and concentration. Further, in eight cases out of 13, deviations from parallelism were non-significant, and in ten cases out of 13 deviations from a linear fit were non-significant. The action of Fluometuron with both perennial and Italian cultivars accounted for the majority of the departures from the perfect fit to the parallel line pattern.

Table 5.

Susceptibilities to seven herbicides of all cultivars (perennials relative to S.24 and Italians relative to EF 486)

*Measurement of this estimate known to lack precision

Herbicide / Cultivar	Dalapon	Simazine	Atrazine	Paraquat	Aminotriazole	Asulam	Fluometuron
			Perennial				
Sceempter	0.4358	0.5504	1.0682	1.6634	0.7797	0.3188	0.6415
S.23	1.3665	1.0665	1.5505	1.5288	1.4544	0.8197	1.5410
R.v.P. Late	1.0519	0.8133	0.7850	0.8770	0.7018	0.6708	1.4779
Kent	0.6613	0.7615	0.6394	1.0590	0.5096	0.6899	1.3944
S.321	0.4563	0.5876	0.5381	0.4454	0.6715	0.4228	0.6256
R.v.P. Early	0.9421	0.6779	0.6109	2.1328	0.8837	1.0645	1.5299
Oriel	1.1179	0.2136	0.5381	2.5364	0.8457	0.1945	0.7271
Presto	0.7972	-	-	0.8021	-	-	1.4745
S. Zephyr	1.1156	0.1845	0.4517	1.5628	0.5987	0.9892	0.7024
S.24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
			Italian				
S.22	1.1863	7.0501*	0.7674	1.5252	-	0.3905	1.7655
St. Ibex	1.3759	7.4993*	0.4944	1.3820	-	0.3906	1.2247
R.v.P.	1.2974	2.5750	0.8980	1.3413	-	0.7343	1.3149
Leda	1.3040	2.1499	0.8187	1.3507	-	0.3912	1.0339
EF 486	1.0000	1.0000	1.0000	1.0000	-	1.0000	1.0000

In Table 5 the susceptibilities of all cultivars (perennials relative to S.24, Italians relative to EF 486) for all herbicides are given. Some cultivars are much more susceptible than others to individual herbicides and the dangers of using certain of these herbicides to control weeds in experimental plots of spaced plants where different cultivars are involved are very apparent.

As these relative susceptibilities are dependent only on the empirical relationship between response and concentration of herbicide and are capable of being reproduced independent of the peak dose (within limits) of herbicide used, it is possible that herbicides could be used diagnostically to classify and identify cultivars just as differential host clones are used to identify and segregate races of fungi. For example, if one + sign is given for each 0.5 interval of the relative susceptibilities of Table 5, the following Table 6 for perennial ryegrass can be constructed.

Table 6.

Reactions of ten cultivars of Lolium perenne to seven herbicides based on data in Table 5.

Herbicide / Cultivar	Dalapon	Simazine	Atra-zine	Para-quat	Amino-triazole	Asulam	Fluo-meturon
Sceempter	+	++	+++	++++	++	+	++
S.23	+++	+++	++++	++++	+++	++	++++
R.v.P. Late	+++	++	++	++	++	++	+++
Kent	++	++	++	+++	++	++	+++
S.321	+	++	++	+	++	+	++
R.v.P. Early	++	++	++	+++++	++	+++	++++
Oriel	+++	+	++	++++++	++	+	++
Presto	++			++			+++
S. Zephyr	+++	+	+	++++	++	++	++
S.24	++	++	++	++	++	++	++

It can be seen that Sceempter and S.321, relatively similar in reaction to most of the herbicides used can be readily distinguished by reaction to Paraquat. Similarly Stormont Zephyr and S.24 can be separated by reaction to Simazine and Atrazine, Stormont Zephyr being much more resistant to both herbicides than S.24.

Further trials, with spraying at 10 and 13 weeks after sowing and on an aftermath growth one week after cutting, are now in progress to determine if similar patterns of reaction emerge independent of stage of grass maturity.

Individual plants irrespective of cultivar, which appear to be resistant to high concentrations of herbicide, will be retained and used in breeding experiments to see if herbicide tolerance is a heritable character.

References

ALLEY, H. LEE, G. and GALE, A. (1966) Grass Nursery (tolerance) study. Weed Control Briefs, Agricultural Extension Service, University of Wyoming.

ARTHUR, T. J. and SHILDRICK, J. P. (1964) Control of Alopecurus myosuroides (Blackgrass) and other grass weeds in grass seed crops. Proc. 7th Brit. Weed Control Conf. 352 - 360.

CHARLES, A. H. and LEWIS, JOSEPH (1962) Observations on the use of herbicides on grassland. Proc. 6th Brit. Weed Control Conf. 1962 1 75 - 83.

ELLIOTT, J. G. and ALLEN, G. P. (1964) The selective control of grasses in permanent pasture. Proc. 7th Brit. Weed Control Conf. 865 - 878.

FINNEY, D. J. (1964) Statistical Method in Biological Assay Chap. 4 : 11.

GOURNAY X. de (1965) La lutte contre les ressemis dans les cultures porte-graines de graminées fourragères. Weed Res. 5 285 - 304.

LEE, W. O. (1964) Chemical control of weeds in Crimson Clover grown for seed production. Technical Bulletin No. 1302. U.S.D.A.

PETERS, R. A. (1964) The selective control of annual grasses in new seedings of perennial grasses. 28th Ann. Rept. of Pasture Research N.E. United States, Pennsylvania.

SPLITTSTOESSER, W. E. and HOPEN, H. J. (1967) Response of bentgrass to siduron. Weeds 15 (1), 82 - 3.

SQUIRES, V. R. (1963) Herbicides for the selective control of barley grass in irrigated clover pastures. Aust. J. Experimental Agric. and Animal Husbandry 3 35 - 38.

THOMPSON, A. (1959) The effect of dalapon on various grass species. Proc. 12th N.Z. Weed Control Conf. 24 - 29.

VENGRIS, J. (1965) Use of grass-killing herbicides in establishing grass-legume mixtures. Agron. J. 57 59 - 61.

WALLIS, J. A. N. (1962) Observations on the differential responses of 40 grass species and strains to low doses of dalapon Pest. Abstr. (C) 8 200-2.

WARREN, R. (1965) Oregon weed control recommendations for grass seed crops. Co-operative Extension Service Leaflet, Oregon State University.

WRIGHT, C. E. (1966) Some implications of genotype-herbicide interactions in the breeding of Lolium perenne Euphytica 15 229 - 238.

ZIEGENBEIN, G. (1964) Herbicides and desiccants in herbage seed crops in the Federal Republic of Germany. Proc. 7th Brit. Weed Control Conf. 1 333 - 341.

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HERBICIDES TO CONTROL SEEDLING WEED GRASSES IN NEWLY SOWN LEYS AND PASTURES

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Summary Two experiments are described in which 'Glenbar' (O,S-dimethyl-tetrachlorothioterephthalate), chlorthal dimethyl (dimethyl 2,3,5,6-tetrachloroterephthalate), applied pre-emergence at doses between 1 and 4 lb a.i./ac and left on the soil surface, gave complete control of the sown weed grasses Agrostis tenuis, Agrostis gigantea and Agrostis stolonifera with no damage to Lolium perenne (S 23, S 24 and S 321) or Festuca pratensis S 53. Holcus lanatus and Poa trivialis were somewhat less affected than the Agrostis species. Mixing the herbicides with the top 2 - 3 in. of soil reduced their activity very markedly. The implications of this selectivity are discussed.

INTRODUCTION

Baker (1962) in a report of a survey of English grassland, showed that the main reason for the deterioration of newly sown leys was the invasion of grass weeds, particularly Poa trivialis and Agrostis species. In 1965 work was begun at the Weed Research Organization on the control of seedling weed grasses in newly sown leys at the time of establishment. From this early work in which the toxicity of a large number of compounds was evaluated in the greenhouse and the field, it became apparent that two related compounds 'Glenbar' (O,S-dimethyl tetrachlorothioterephthalate) and chlorthal dimethyl (dimethyl 2,3,5,6-tetrachloroterephthalate) were very toxic to germinating seedlings of Agrostis spp. and relatively non-toxic to seedlings of Lolium perenne and several other grass species. This report describes two field experiments, one in 1967 and the other in 1968 on the use of 'Glenbar', chlorthal dimethyl and (1968 only) OCS 21693 (methyl 2,3,5,6-tetrachloro-N-methoxy-N-methyl terephthalamate), for the control of seedling grass weeds in newly sown leys.

METHOD AND MATERIALS

A normal seed bed was prepared on sandy loam soil at the Weed Research Organization and 1.25 cwt of 40.20.20 fertilizer applied. In the 1967 experiment 1 yd^2 plots were sown by hand on 20/4/1967 with three different mixtures of species: A. Lolium perenne S 23, Trifolium repens, S 100, Agrostis tenuis and Holcus lanatus; B. L. perenne S 23, T. repens S 100, and Agrostis gigantea; C. Festuca pratensis S 53, Poa trivialis and A. tenuis. The different grasses were sown individually on the soil surface using a special distributor, and the species other than the Agrostis species lightly raked in before all were rolled. Immediately after sowing the herbicide treatments (as listed in Table 1) were applied by a special sprayer for small plots at a volume rate of 50 gal/ac using an Allman 0000 nozzle at a pressure of 30 lb/in^2. The experimental design was a randomised block of two replicates with the herbicide treatments and species mixtures fully randomised.

In the 1968 experiment the following mixtures of species were sown, as in the 1967 experiment, using an Amazone seed drill, in strips of 2 yd wide on 21/4/1968: D. L. perenne S 23, A. tenuis and H. lanatus; E. L. perenne S 24 and A. gigantea; F. L. perenne S 321 and Agrostis stolonifera. The herbicide treatments listed in Table 2 were applied in 1 yd swaths across the sown strips using an Oxford Precision Sprayer fitted with 8002 Teejets, delivering 20 gal/ac at 30 lb/in^2. The pre-drilling treatments were applied to the soil surface, mixed into the top 2 - 3 in. with a small rotary cultivator mounted on a Ransome MG 40 tractor and rolled before sowing. The post-drilling treatments were applied immediately after sowing and rolling. The experimental design was again a randomised block replicated twice, with the herbicide treatments fully randomised. Each main plot (or herbicide treatment) was however divided into sub plots for each of the three different types of sward.

The 1967 experiment was assessed approximately 6 weeks after treatment by counting the number of plants of each species present in six 3 x 3 in. quadrats placed at random on each plot. A point quadrat was used for the 1968 experiment and the first hit of each species recorded on each of 100 points per sub plot, thus giving the percentage cover of each species.

RESULTS

The results from the two experiments are summarised in Tables 1 and 2.

Table 1

Selective control of sown weed grasses in *L. perenne* S 23, *F. pratensis* S 53 and *T. repens* S 100

Counts of plants present in six 3 x 3 in. quadrats 6 weeks after treatment - mean of 2 replicates

Herbicide	*dose lb/ac	Mixture A				Mixture B			Mixture C		
		S.23	TR	AT	HL	S.23	TR	AG	FP	PT	AT
'Glenbar'	2	25	11	0	11	25	12	0	19	54	2
Chlorthal dimethyl	2	22	6	0	7	29	16	0	14	38	4
	4	23	8	0	6	32	9	0	14	19	2
Control	-	26	15	39	11	30	17	55	14	59	45
S.E. treatment means	±	4.5	4.2		5.1	4.9	4.1		2.3	11.0	19.7
S.E. control means	±	2.8	2.1	4.7	2.5	2.5	2.1	5.4	1.2	7.8	9.8

Key: S 23 = *L. perenne* S 23, TR = *T. repens* S 100, AT = *A. tenuis*, HL = *H. lanatus*, AG = *A. gigantea*, FP = *F. pratensis* S 53, PT = *P. trivialis*

*All doses are in terms of the ester

The results from both experiments show that none of the treatments had any marked effect on the various strains of *L. perenne*. The clover in the 1967 experiment was somewhat reduced, particularly by the higher dose of chlorthal dimethyl, but the other crop grass, *F. pratensis*, was relatively unaffected.

Of the weed grasses, the two *Agrostis* species were almost completely eliminated by all the treatments. *H. lanatus* and *P. trivialis* were considerably more resistant although their numbers were reduced, particularly by the higher dose of chlorthal dimethyl.

The second experiment showed very clearly that mixing with the soil, reduced the activity of all three herbicides on the *Agrostis* spp. very markedly. 'Glenbar' and chlorthal dimethyl appeared to be influenced less than OCS 21693. However all the treatments in which the herbicide was left on the soil surface gave excellent control of the three *Agrostis* species. *H. lanatus* was considerably more resistant although its cover was very much reduced by the higher dose of the herbicides.

Table 2

Selective control of sown weed grasses in S 23, S 24 and S 321 *L. perenne*

No. of first hits of each species/100 points, 6 weeks after treatment - means of 2 replicates

Herbicide	*dose lb/ac	Mixture D: herbicide mixed in			Mixture D: herbicide on surface			Mixture E: herbicide mixed in			Mixture E: herbicide on surface			Mixture F: herbicide mixed in			Mixture F: herbicide on surface		
		S32	AT	HL	S23	AT	HL	S24	AG	BG	S24	AG	BG	S321	AS	BG	S321	AS	BG
'Glenbar'	1	71	30	35	73	5	16	92	24	5	94	4	7	95	44	3	93	7	7
	2	82	9	14	85	3	10	92	7	5	90	7	5	98	47	2	99	3	3
Chlorthal dimethyl	2	71	11	16	80	1	18	85	17	4	87	4	12	88	33	6	96	1	10
	4	75	8	14	78	1	6	91	2	9	76	0	20	84	23	9	91	0	14
OCS 21693	1	74	36	24	85	5	14	90	27	7	91	3	13	97	52	0	96	14	5
	2	78	22	16	78	0	7	94	20	11	77	1	23	87	49	0	85	4	20
† Control		74	20	15	80	20	23	89	23	5	88	19	5	94	49	1	96	43	2
S.E. treatment means ±		9.6	6.5	7.0	6.8	3.0	4.3	3.2	7.9	2.8	4.9	6.2	3.7	7.1	15.8	3.1	3.0	5.2	4.4
S.E. control means ±		5.6	3.7	4.0	3.9	1.7	2.4	1.9	4.5	1.6	2.8	3.6	2.2	4.1	9.0	1.8	1.7	3.0	2.5

† Control mean of six replicates   * All doses are in terms of the ester

Key: S 23 = *L. perenne* S 23; S 24 = *L. perenne* S 24; S 321 = *L. perenne* S 321; AT = *A. tenuis*; HL = *H. lanatus*; AG = *A. gigantea*; BG = bareground; AS = *A. stolonifera*.

DISCUSSION

These results indicate very clearly that under the conditions of these experiments all three herbicides when left on the soil surface gave a highly selective control of germinating seedlings of A. tenuis, A. gigantea and A. stolonifera in L. perenne. When the herbicides were mixed with the soil, they were still selective but their activity was reduced.

The high activity of the surface applications must be treated with some reserve as the conditions in both experiments were artificial in that: 1) the weed seeds were sown with the crop grasses and were not already present in the soil - as in the natural situation; 2) all three Agrostis spp. require some light for germination and were therefore sown very near to or on the soil surface where they were subjected to a relatively high concentration of herbicide. However in the natural situation it seems highly likely that due to their requirement of light for germination, the seeds which germinate are very near to, or on, the soil surface. In greenhouse work (not reported here) when seeds of various Agrostis spp. were sown at different depths there was a very marked reduction in the numbers which germinated as the depth of seeding was increased. Chlorthal dimethyl and 'Glenbar' were however still very toxic to deeper germinating seeds.

The work described here opens up attractive new possibilities for dealing with the problem of weed grasses in leys through attack at the outset. Weed invasion can be most potent if it occurs at the time at which the crop grasses themselves are becoming established and before they are competitive. Agrostis spp. are a major problem in this context and the selectivity here shown could be of major practical value. It must however be borne in mind that these herbicides are only likely to be effective on seedlings and will probably not deal with invasion through regeneration from vegetative material.

The present work is being extended into more natural situations. Other facets which will influence the utilisation and value of this selectivity are currently being investigated, notably the persistence of these herbicides in the soil and the effect of the relative positions of germinating seed and herbicide. Further herbicides are also under investigation for selectivity relevant to this type of usage.

Acknowledgements

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References

BAKER, H.K., (1962) A survey of English grasslands. Proc. 6th Brit. Weed Control Conf. 23-30.

Proc. 9th Brit. Weed Control Conf. (1968)

EXPERIMENTAL WORK IN THE CHEMICAL CONTROL OF BRACKEN 1958-1968

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Summary From a large number of herbicides tested for the control of bracken on unploughable land capable of bearing a productive grass sward only aminotriazole at 7.5 lb a.i./ac, dicamba at 4 to 6 lb a.e./ac, and picloram at 3 lb a.i./ac have consistently given adequate degrees of control.

With dicamba and picloram the timing of application is not critical, but in the case of aminotriazole optimum results are obtained only when application is made at the time when the frond is almost fully unrolled. The effect of formulation, dose rate and water carry is described. Aminotriazole had negligible effect on the underlying herbage, but dicamba and picloram eliminated all broad-leaved plants from the sward and dicamba also seriously interfered with the growth of grass.

The practical implications of the use of these herbicides is considered, and as leguminous plants are essential to the improvement of the herbage, it is concluded that only aminotriazole is suitable for use in this respect.

INTRODUCTION

Trials to determine a suitable selective herbicide for the control of Pteridium aquilinum (bracken) were begun in 1958 following three years work with non-selective herbicides. They have been particularly directed to sites having a good grass sward underlying the fronds, as the major bracken control problems in the east of Scotland come under these situations. In these conditions the ideal chemical treatment, in addition to giving a high degree of control, must not cause other than a temporary suppression to the grass growth and should not produce residues in the soil which could interfere with the subsequent improvement of the sward and in particular prevent the establishment of legumes.

Because it is usually impracticable to exclude livestock from any area under treatment, it is essential that the herbicide employed should be non-toxic to animals, and that dead or dying bracken fronds offer no residual effect to the stock. In fact, none of the herbicides mentioned in this paper appeared to have any effect on the grazing animal, as in all cases, with the exception of the preliminary work with picloram, animals were not excluded from the trial areas even when the plots were being sprayed. It was also noted that stock tended to avoid grazing the treated areas as the fronds withered after foliar treatment.

MATERIALS AND METHODS

The herbicides used in the series are listed in the following section.

In the early years of the experimental programme, treatment with liquid formulations was by the Oxford Precision Sprayer on plots averaging 48 sq yd. Except when investigating the rate of water carry, materials were applied in the equivalent of 60 gallons water per acre. Experience showed that such plots were too small in that bracken re-infestation from the untreated margins of the plots soon covered the entire plot and made assessment of control impossible, thus all further small plot work was on plots 10 or 20 yards square, using the O.P.S. booms fitted to a Drake and Fletcher 'Mistifier' knapsack sprayer. In addition larger plots varying in size with the availability of herbicide and ranging from $\frac{1}{8}$th to 1 acre were treated using a Land-Rover sprayer or a conventional tractor-mounted field-crop machine.

Granular formulations were applied by hand to small plots of between 50 and 100 sq yd because of the limited quantities available.

Except in the case of 1 acre and $\frac{1}{2}$ acre plots, which were intended primarily as demonstrations, all trials were replicated although on some sites it was necessary to separate the replicates to obtain similar densities of infestation at the start of a trial.

Assessment of the degree of control has been based on frond counts on treated and adjacent untreated areas, normally carried out in August or early September when the bracken is in full frond and before the first autumn frosts affect the canopy. The control percentages quoted in the results refer to the degree of reduction in frond numbers over the untreated control, where 100% is total absence of fronds and 0% signifies frond cover as on untreated areas. Figures are given only when statistical analysis indicates significance at the 10% level.

Experience with the control of bracken and discussions with the farmers concerned suggests that a control of 90% would be acceptable in practice, and that a figure of 95% or above would be considered excellent for most practical purposes. As the trials were normally conducted on bracken stands averaging 60 fronds per square yard, such control percentages would result in a population reduced to 6 fronds and not more than 3 fronds respectively per square yard.

RESULTS

Because of the number and variety of trials it is not possible in this paper to quote all relevant numerical data: the following therefore summarises the findings related to each basic herbicide, there being a total of 47 trials on 21 sites.
aminotriazole: This was used in the formulation activated with ammonium thiocyanate ('Weedazol-TL'). Although doses as low as 2.5 lb a.i./ac gave some degree of control in the season following treatment, the control was short lived and the level (averaging 60%) not sufficient in practice. Doses from 5 to 7.5 lb/ac produced much enhanced and long-lasting control entirely acceptable in practice; plots treated in 1959 on assessment seven seasons later (1966) gave a degree of control averaging 75%, a low figure due to re-infestation from the edges of plots. One acre plots, treated in 1959 with 7.5 lb/ac were in 1968 virtually free of bracken in the centre area although the re-infestation from the edges in these nine seasons has resulted in a 'narrowing' of the plots by some 30 feet all round.

From a series of timing trials, it was found that optimum results may be obtained from application just before the fronds fully unroll, and this time of application appears to be critical within a period of not exceeding 4 weeks; the control figures from applications made 3 weeks before or after this optimum stage rarely exceeding one-half of the maximum. Provided there was sufficient solution to give effective cover of the fronds, water carry had no significant effect on the degree of control.

Except in cases where excessive run-off occurred with high (over 100 gal/ac) water carry rates, no permanent effect was detected on the underlying sward even at doses of 15 lb/ac although for about one or two months after treatment a slight scorch was visible.

4-CPA (p-chlorophenoxyacetic acid) and related compounds: A large number of formulations of 4-CPA have been extensively tested, but most of the detailed work has been with commercially available amine salts and ester formulations, both of which have given satisfactory results. With 4-CPA the degree of control has been more or less proportional to the dose rate, and in the 7.5 to 10 lb a.e./ac region resulted in 85% control in the season following application. Duration of control has been less than with aminotriazole and all trials regained original infestation densities four seasons after treatment.

As with aminotriazole, the water carry had little effect on efficiency. Timing of application for optimum effect was more critical than with aminotriazole and the best time appeared to be when the frond was fully unrolled, applications a week to ten days before or after this time resulted in very much reduced control. At no time had any formulation of 4-CPA any effect on the underlying herbage, but doses required to give reasonable bracken control always severely reduced the broad-leaved components of the sward.

Amine formulations were more effective than esters. Water-in-oil (invert) emulsions of the esters in turn were superior to oil-in-water emulsions but were still inferior to the amine formulations excepting under very wet conditions. Sodium, potassium, lithium and ammonium salts of 4-CPA, 4-CPA ethyl sulphate and 4-CPA acid in an emulsifiable formulation offered no advantages over the commercial formulations at equivalent doses. Work on a number of compounds based on 4-chlorophenoxybutyric acid and 4-chlorophenoxypropionic acid produced no promising candidate herbicides. Granular formulations on sepiolite and oolitic limestone were also tested but were found inferior to liquid formulations at equivalent doses.

dalapon-sodium: This chemical, in the commercial formulation containing a wetter, was tested at rates from 5 to 20 lb a.e./ac. Although the first impressions the following spring suggested that a very high degree of control was present, by the summer the bracken had recovered to almost the level of untreated areas, the herbicide simply delaying by some four to six weeks the emergence of the frond. All rates produced severe damage to the grasses of the sward, and even five seasons after application the underlying sward consisted predominantly of broad-leaved weeds with rates exceeding 10 lb/ac.

dicamba: Only the sodium salt formulation of this chemical was tested, and the optimum dose was found to be 6 lb a.e./ac as a foliar application in summer, and 4 lb/ac as a pre-emergence application in the spring. These rates gave 100% control in the season following treatment, but in the second season control had reduced to 50%, reverting to zero in the third season. All rates led to total destruction of the sward irrespective of the time of treatment; grass only began to re-establish two seasons after treatment, at which time some broad-leaved weeds (principally perennial nettle) appeared. On one site a direct re-seed was attempted two years after spraying, but although there was a reasonable take of perennial ryegrass, the white clover establishment was of a very low order.

diquat-dibromide (and other bipyridyls): Although tested over a range of doses from 0.25 to 2 lb ion/ac the most effective rate appears to be 0.5 lb/ac, higher or lower rates giving inferior control. At the 0.5 lb/ac dose there was an immediate kill of fronds and plots remained free of bracken during the season. The first season after treatment showed an average control of 75%, reducing slightly the next season to 70%. By the third season the control had reduced to 20%. If however, a repeat dose of 0.5 lb/ac was made the season after the first treatment, the control figure for the following season reached 90%, falling to 60% on the next and to 20% on the fourth season after initial spraying. Water carry was not of any significance, but the best results were obtained if the herbicide was applied when the fronds were between 9 and 12 inches tall. The 0.5 lb/ac dose produced temporary scorch of the sward, but this did not persist. Formulation was important, and only the proprietary product containing a wetter ('Preeglone') gave the above control; the unwetted 'Reglone' gave very low control figures, as did paraquat-dichloride and morfamquat-dichloride.

MCPA: This herbicide has been included in trials from 1955 to date, and although in a few cases some high degrees of control have been attained it has been found impossible to obtain consistent results.

picloram: Of all herbicides included in trials, picloram has produced the best and most consistent results. Although a range of doses from 0.5 to 4 lb a.e./ac was included in most experiments, those of 3 lb/ac and over regularly gave complete control of the infestation; on some sites 2 lb/ac produced 100% control the following season, whereas on others the figure tended to be in the 90% region and the discrepancies could not be correlated with timing of application, climatic or edaphic factors. In general applications of picloram in the autumn after frost had killed the fronds, or in spring during the period from the disappearance of snow to the first emergence of fronds, gave the best results including 100% control in that season; applications in the early post-emergence stage when the fronds were not more than 12 inches high were equally successful with liquid formulations but markedly inferior with granular formulations, and these later applications seldom gave complete control during that season. The amount of water carry with liquid formulations had no significant effect on the eventual control. The duration of bracken control given by picloram, irrespective of formulation, was less than that from aminotriazole; for the two seasons following treatment control figures between 95 and 100% were normal, reducing in the third season to between 50 and 70%, and virtually disappearing in the fourth season. Of the formulations tested that containing picloram in an emulsifiable state was markedly inferior at equivalent rates to water soluble liquid formulations based on the potassium salt and to granular formulations. Even at the maximum dose stated, picloram had no effect on the grasses of the underlying sward, whereas at the lowest dose (0.5 lb/ac) a complete eradication of all broad-leaved plants occurred. It was not possible to establish clover to any extent on plots twelve months or less after treatment but some establishment was made in the third season after treatment at the optimum rate of 3 lb/ac.

Other chemicals: Many other herbicides were tested in this programme but the control of bracken was of such low level, or the chemical possessed other disadvantages making them unsuitable for commercial use. These chemicals included PCP, PCP(Na), dichlobenil, dimexan, 2,4,5-T, 2,4-D, erbon, mecoprop, dichlorprop, fenoprop, MCPB, 2,4-DB, chloramben, chlorfenac, SMA, TCA, sodium trichloropropionate, methiuron.

DISCUSSION AND CONCLUSIONS

From the results quoted above, it is apparent that the most effective herbicides for the control of bracken are aminotriazole, dicamba and picloram. The main drawback to the use of aminotriazole is the necessity for application when the fronds are approaching full height; this can be a difficult and sometimes dangerous operation with land sprayers because of the ever present risk of obstacles hidden by the bracken which could damage or capsize the tractor and sprayer. There are, of course, large tracts of bracken infested grazing in the east of Scotland more or less free of such hazards and the use of aminotriazole with its supreme advantage of negligible effect on the sward is a possibility in such areas. However as the suggested dose (7.5 lb/ac) would cost £11 per acre for chemical alone, such a treatment is not a practical proposition in the present economic climate on such upland farms.

The advantage with dicamba and picloram of treatment before the bracken emerges, when the tractor operator can see and avoid obstacles, coupled with the high degrees of control afforded is an extremely attractive proposition. However the serious damage caused to the whole sward by dicamba, and the delay which could occur in regaining the grazing renders this treatment one of limited use and in general unattractive to the farmer. Although picloram eliminates the broad-leaved components, it is fairly safe as regards the grasses provided that there was no necessity of establishing legumes in the sward in the immediate future. Control of bracken with picloram is an undoubted practical possibility on the assumption that the cost of treatment could be kept to a level which would be economic.

The ultimate objective in any scheme for the control of bracken is higher productivity by the improvement of grazing, and the improvement of grazing can only occur if the quality of the herbage is raised. It is usually not possible to stock upland pastures intensively and thus ensure ample return of nitrogen from the animal, neither is it economically feasible to supply sufficient nitrogen by means of artificial fertilisers to raise the quality of the herbage. In such situations the principal source of nitrogen is the atmosphere with leguminous plants converting this into a form which can be utilised by grasses. The retention and increase of legumes in the sward is therefore a critical factor in the improvement of grazing.

Picloram and dicamba may possess high efficiency in controlling bracken and may be less dependent on critical timing of application than is aminotriazole, but against this the disastrous effect on the legumes of the herbage and the problems of residues must take precedence. For these reasons it is concluded that aminotriazole offers the greatest promise for the control of bracken in the situations described in the introduction to this paper.

It has been very noticeable on the experimental sites that when a high degree of control of bracken has been attained, there is a tendency for stock to congregate on the treated areas and to keep these areas well grazed and by trampling further hold the bracken in check.

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A PROGRESS REPORT ON THE USE OF PARAQUAT, PICLORAM AND DICAMBA ON BRACKEN (*Pteridium aquilinum* (L) Kuhn) DOMINATED HILL PASTURE.

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Summary Bracken dominated hill pastures at approx. 900 feet were treated with paraquat for attempted selective control of the underlying Agrostis/Poa sward, picloram or dicamba for the control of bracken and subjected to two reseeding techniques with a ryegrass-clover mixture. Two factorial experiments are described - the first using fertilizers and cutting of the bracken and grass, the second conducted on the unimproved native pasture with the bracken cut for yield estimation only after senescence. To date picloram has given better control of bracken than dicamba at equivalent dose rates and paraquat, or light cultivations, have achieved considerable control of the native sward and enhancing a better take of the ryegrass-clover mixture.

INTRODUCTION

There have been many previous trials attempting a chemical control of bracken. The position up to 1964 has been adequately summarised by Hodgson (1964a). Since 1964 interest has centred principally around the use of picloram and dicamba (Hodgson 1964b, Lawson 1964, Hodgson and Donaldson 1966, Martin 1968). The ultimate objective of bracken control in agriculture is the improvement of the underlying native sward or in the absence of a native sward, the establishment of a new one. Hodgson (1964a) stated two of the outstanding problems in chemical bracken control research to be:- 1. The evaluation of picloram and dicamba. 2. The development of agronomic techniques which will allow successful reclamation. This study is an attempt to investigate the two problems simultaneously.

METHODS AND MATERIALS

Experiment 1 was a 3 x 2 x 2 factorial involving:-

Factor 1.	No chemical for bracken control (untreated)
	Picloram 3 lbs. a.i./acre in 30 galls. applied February 1967
	Dicamba " " " " "
Factor 2.	No Paraquat
	Paraquat 1 lb. a.i./acre in 30 galls. applied December 1966
Factor 3.	Oversowing 30 lbs. S23 Perennial ryegrass + 2 lbs. S100 wild white clover during April 1967 (Oversowing, no cult.)
	Oversowing 30 lbs. S23 perennial ryegrass + 2 lbs. S100 wild white clover during April 1967 after light rotary cultivation (Oversowing with surface cult.)

All treatments received 3 tons lime/acre December 1967, and 67.2 lbs. of N and P. and 100.8 lbs. of K per acre at the time of oversowing. No cultivations followed reseeding. Plot size was 6 yds. x 4 yds. and each treatment was replicated four times. Three cuts for bracken and grass yield were taken in 1967, bracken being removed the day prior to cutting the grass and three similar cuts have been taken to date in 1968. Nitrogen (44.8 lbs./acre) has been applied after each cut except the last of each year in 1967 and 1968. Grass samples taken in 1968 were analysed for in vitro organic matter digestibility. In December 1967 ten - $4\frac{1}{2}$ in. diameter cores of turf were taken from each plot (method adapted from Mitchell and Glenaday 1958 and Allen 1967) and grown on for 28 days in a glasshouse maintained at approx. 60° F with a 16 hr. photoperiod, prior to counting the tillers of individual grass species present.

Experiment 2 was a 2 x 2 x 3 factorial involving:-

Factor 1. Picloram
Dicamba

Factor 2. Granular formulation (picloram 11.6% granules, dicamba 10% granules).
Spray formulation at 30 galls./acre.

Factor 3. 1 lb. a.i./acre.
2 lbs. a.i./acre.
3 lbs. a.i./acre.

An untreated control was also included. Chemicals were applied in March 1967 and plot size, treatment replication and pasture sampling were as in expt. 1. Four one foot square quadrats were placed in each plot under the bracken canopy and grass was cut by hand three times in 1967 (Quadrat cuts). The dead bracken fronds were cut from the plots in October 1967 for yield estimation and then another grass cut taken by machine (machine cut) for comparison with the quadrat cuts.

RESULTS

Discussion and presentation of results from the two experiments is restricted to the salient main factor effects.

Expt. 1 No clover established in the picloram treated plots. Table 1 shows that for the three cuts in 1967 grass yields were marginally higher in the picloram treated plots - also reflected in total digestible organic matter (D.O.M.) production for the year. To date in 1968, picloram treatments are yielding marginally lower than the untreated and dicamba treatments. The use of paraquat and reseeding with cultivation gave lower dry matter (D.M.) yields for 1967. However due to higher D.O.M. levels in the cultivated and reseeded treatments, a higher D.O.M. yield for the year was obtained. In 1968 the use of paraquat and reseeding with cultivations are giving higher yields. Table 2 shows the more or less complete control of bracken with picloram and intermediate control with dicamba in 1967 but almost equivalent control with the two chemicals in 1968 after a year of regular cutting. Untreated plots showed dramatic reduction in bracken by 1968, but control is still far inferior to that obtained with chemicals. Where paraquat was used a poorer control of bracken was obtained in 1967. In table 3 picloram and dicamba are shown to have little effect on the frequency of the principal grass species except for an increase in *Poa pratensis* with both chemicals and a decrease of *Poa trivialis* with dicamba. The mean of a random sample of 50 cores taken from around the plot area in June 1967 gives a reference value for the native sward.

Table 1

Expt. 1. Grass & Clover D.M. and D.O.M. yields (lbs./acre) for 1967 and 1968

T'ment	Cut 1 1967 D.M.	Cut 2 1967 D.M.	Cut 3 1967 D.M.	1967 Total D.M.	1967 Total D.O.M.	Cut 1 1968 D.M.	Cut 2 1968 D.M.	Cut 3 1968 D.M.
Untreated	296	870	1277	2442	1418	2303	1698	1268
Picloram	336	1104	1420	2860	1681	2104	1579	1144
Dicamba	287	973	1386	2646	1502	2394	1714	1385
No Paraquat	567	1187	1360	3115	1728	2125	1652	1199
Paraquat	45	777	1361	2184	1340	2432	1676	1332
Direct reseed	560	1002	1212	2774	1234	1911	1597	1155
Cultivate, reseed	52	962	1510	2525	1806	2646	1731	1376

Table 2

Expt. 1. Bracken frond (no./sq.yd.) and frond D.M. production (g/sq.yd.) for 1967 and 1968.

T'ment	Cut 1 1967 D.M.	Cut 2 1967 D.M.	Cut 3 1967 D.M.	1967 Total D.M.	1967 Total no. of fronds	Cut 1 1968 D.M.	Cut 2 1968 D.M.	Cut 3 1968 D.M.
Untreated	80.8	113.5	0.3	194.6	51.8	0.7	28.1	3.4
Picloram	0.1	0.5	0	0.6	0.9	0.2	1.8	1.0
Dicamba	23.0	6.5	0	29.5	28.1	0.2	6.5	0.7
No Paraquat	28.2	36.0	trace	64.2	21.9	0.2	11.6	1.7
Paraquat	41.1	44.3	trace	85.4	31.9	0.2	12.7	1.7
Direct Reseed	33.2	23.1	trace	56.3	18.8	0.2	10.2	1.8
Cultivate, reseed	36.1	57.2	trace	93.3	35.1	0.2	14.0	1.7

Table 3

Expt. 1. Pasture analysis. Tillers/4½ in. diam. core at Dec. 1967

T'ment	S 23	*Poa pratensis*	*Poa trivialis*	*Agrostis* sp.
Untreated	20.7	11.5	32.4	20.3
Picloram	19.8	19.6	32.4	21.4
Dicamba	18.2	25.7	21.3	20.1
No Paraquat	5.7	28.9	33.8	35.4
Paraquat	33.4	9.0	23.6	5.8
Oversowing, No Cult.	12.2	22.3	40.5	25.7
Oversowing with surface cult.	26.9	15.6	16.9	15.5
Random Sample Exptl. area June 1967	0	13.8	4.2	36.8

Expt. 2 The grass D.M. yields for 1967 (Table 4) indicate both cutting techniques to have illustrated the same treatment trends although giving different values. Greater yields were obtained with picloram than dicamba but yields on picloram treatments fell with increasing dose rate and rose with increasing rates of dicamba. All treatments showed marked increases in yield over untreated plots. In Table 5, the greater efficiency of picloram over dicamba for controlling bracken is illustrated. Granular forms of both chemicals were superior to spray (still observable in 1968). An increase in frequency of the principal native grass species was observed on most treatments (Table 6) when compared with untreated plots. The frequency of *Anthoxanthum odoratum* is increased more with picloram than dicamba.

Table 4

Expt. 2. Grass Yields lbs. D.M./acre 1967.

T'ment		1	2	3 lbs. a.i./acre
Picloram)	3 Quadrat cuts	1693	1621	1398
Dicamba)		1067	1426	1473
Picloram)	1 Machine cut	1012	878	820
Dicamba)		549	857	955
Untreated		Quadrat = 383		Machine = 198

Table 5

Expt. 2. Bracken frond (no/sq.yd.) and frond D.M. (g/sq.yd.) 1967

	Fronds/sq.yd. 1	2	3	D.M. g/sq.yd. 1	2	3 lbs a.i./acre
Picloram granules	5.8	1.2	0.3	25.1	3.8	0.4
" spray	11.8	5.8	0.8	61.2	16.8	17.3
Dicamba granules	39.3	32.7	18.2	246.6	127.9	59.1
" spray	43.8	42.2	37.2	327.7	244.1	145.0
Untreated		38.4			348.1	

S.E. ± 3.47. Coeff. of Var. = 25% S.E. ± 16.39 Coeff. of Var. = 31%

Table 6

Expt. 2. Pasture analysis. Tillers/4½ in. diam. core. Dec. 1967

T'ment		Anthoxanthum odoratum	Agrostis sp.	Poa pratensis
	1 lb. a.i./ac.	13.2	55.7	3.4
Picloram	2 " "	15.1	55.3	2.3
	3 " "	16.2	47.2	1.2
	1 lb. a.i./ac.	3.2	35.1	3.3
Dicamba	2 " "	2.2	61.4	3.7
	3 " "	4.6	54.1	4.4
Untreated		1.9	25.3	2.4

DISCUSSION

Conclusions drawn at this stage in the project are necessarily tentative. To date bracken has been controlled more effectively with picloram than dicamba and granular forms of both have been superior to spray - possibly because there is a slower release of chemical over a longer period of time. However in Expt. 1 picloram and dicamba in conjunction with regular cutting of bracken are giving more or less equal control - the possibility of combining herbicidal with mechanical treatments is suggested. Surprisingly the use of paraquat increased bracken levels in 1967 and it is thought that the dead surface mat was presenting less of a physical barrier to frond emergence.

The potential of this type of hill pasture for improved grassland production is indicated in both expts. Grass yields have been depressed by picloram in 1968 (Expt. 1) and 1967 (Expt. 2) pointing to a possible toxic effect. Cutting grass from small quadrats under the bracken canopy is suggested as a useful technique for studying grass productivity under bracken - the higher grass yields from this technique being due to increased frequency of cutting compared with the single machine cut. Paraquat and light rotary cultivations have shown similar results in controlling the native sward, however, results not printed here show interactions between the two factors in this context (Farnworth 1968).

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References

ALDHOUS J.R. (1966) Bracken control in Forestry with Dicamba, Picloram and Chlorthiamid.

ALLEN G.P. Personal communication.

FARNWORTH J. (1968) Unpublished data, University College of North Wales.

HODGSON G.L. (1964a) A.R.C. Weed Research Organisation Tech. rept. No. 3 Chemical control of Bracken.

HODGSON G.L. (1964b) Sodium 3, 6 - dichloro - 2 - methoxy benzoate for the control of bracken (Pteridium aquilinum (l) Kuhn): Results of preliminary trials Weed Res. 4. 167-168.

HODGSON G.L. DONALDSON I. (1966) Herbicides on bracken (Pteridium aquilinum (L) Kuhn). Trials with Dicamba and Picloram. Proc. 8th Brit. Weed Control Conference 360-361.

LAWSON H.M. (1964) The control of bracken fern with 4 - amino- 3, 5, 6 - trichloropicolinic acid. Research Summary. Proc. 7th British Weed Control Conference 887- 890.

MARTIN D.J. (1968) Bracken control trials in West Scotland. European Grassland Federation. Symposium on Hill Land Productivity Paper 29.

MITCHELL K.J. GLENADAY A.C. (1958) The tiller population of pastures. N.Z.J. Agric. Res. 3. 305-313.

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CONTROL OF BRACKEN FERN WITH HERBICIDES

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Summary Preliminary trials carried out in 1966 indicated that both 4-amino, -3,5,6-trichloropicolinic acid (picloram) and the dimethylene salt of 2-methoxy-3,6-dichlorobenzoic acid (dicamba) gave good control of bracken (Pteridium aquilinum L.).

In 1967, replicated trials were laid down at three centres, a, b, and c with picloram at 1.25, 2.4 and 3.3 lbs (a.i.) per acre and dicamba at 4, 6 and 8 lbs (a.i.) per acre. At centre (a) the herbicides were applied one week before frond emergence, at centre (b) when the fronds were emerging, and at centre (c) when the fronds were unfurled and about seven inches above the ground.

Assessments at four and fourteen months after treatment showed that the pre frond emergence application of both herbicides gave the most effective control of bracken.

INTRODUCTION

Bracken fern is one of the most persistent weeds present in upland pastures in Britain and Ireland. Its particular importance is that it occupies soils which are potentially good for pasture land, (Tansley 1949).

Until recently control measures were mainly mechanical, but due to the steep slopes on which this weed occurred, effective treatments were difficult to carry out.

Between 1958 and 1962, dalapon, amino triazole and 4-CPA, had been studied with varying degrees of control.

Hodgson (1962) reporting a trial in which sixteen herbicides were screened found that dicamba was by far the most promising herbicide for bracken control. Subsequently Hodgson (1964) again reported effective bracken control with dicamba. Aldhous (1964) also reported that dicamba gave complete control of bracken fern for the growing season in the year after treatment, when applied in April, May or June at rates from 4 lbs (a.i.) per acre.

Lawson (1964) reported that 4-amino-3,5,6-trichloropicolinic acid (picloram) gave excellent control of bracken for two full seasons after treatment. Lhoste et al (1964) reported similar results with this herbicide.

Hodgson and Donaldson (1966) reported that doses of 2 to 4 lbs (a.i.) per acre of either chemical was capable of a high degree of control for at least three years, if applied at the correct stage of bracken growth.

Trials carried out in Ireland, with picloram and dicamba gave promising results, Mitchell (1966). Trials continued in 1967 and 1968 and the results are reported in this paper.

METHODS AND MATERIALS

For these experiments, three sites, designated a, b and c were chosen in areas of established heavy bracken infestation.

Plot size was 10 yds x 4 yds with suitable discard areas in between plots. All these trials were of randomised block design with four replications per treatment.

Picloram (4-amino-3,5,6-trichloropicolinic acid) and dicamba (2-methoxy-3,6-dichlorobenzoic acid), were used at 1.25, 2.4 and 3.3 lbs (a.i.) per acre and 4, 6 and 8 lbs (a.i.) per acre respectively. Both herbicides were applied as salt formulations in a volume of water equivalent to 20 gallons per acre. Application at centre (a) was made with an Azo Propane sprayer and at (b) and (c) with an Oxford Precision sprayer.

At centre (a) the herbicides were applied to the ground litter seven days before frond emergence. At centre (b) application took place at frond emergence, while at (c) the fronds were unfurled to the extent of seven inches above the ground.

Frond counts were carried out four and fourteen months after treatment. There were four counts per plot at (a), and three counts per plot at (b) and (c). A square yard quadrat was used in all cases. The resultant control was expressed as a percentage reduction in frond number compared with the untreated plots.

RESULTS

Table 1 shows that at centre (a) all the treatments showed excellent bracken control four months after application. The picloram gave excellent results at all rates. Dicamba gave good control at the lowest rate and excellent control at the two higher rates. Most of the fronds present in the plots treated with 4 lbs/acre of dicamba were severely damaged.

Table 1

Effect of different concentrations of picloram and dicamba on bracken fern assessed four months after application

Herbicide	Rate per acre lbs (a.i.)	% control centre (a) Pre-emergence	centre (b) At-emergence	centre (c) Post-emergence
1) Picloram	1.25	99	88	67
2) Picloram	2.4	100	89	71
3) Picloram	3.3	100	99	82
4) Dicamba	4.0	68	86	35
5) Dicamba	6.0	83	91	56
6) Dicamba	8.0	88	97	62
7) Untreated	-	-	-	-

In a number of these plots dense clumps of bracken thrash appeared to give some degree of protection to the fronds against the herbicides. Any fronds that grew up through these clumps did not appear to be as severely damaged as those with no "clump protection".

At centre (b), where the herbicides were applied at frond emergence, picloram gave satisfactory control at all rates. At the lowest rate there were some fronds present, but these were blackened and distorted. In this trial dicamba also gave excellent control. The results were in general superior to the results obtained at centre (a). This is attributed to the tender stage of growth of the bracken at the time of spraying. At centre (c) results were variable. Picloram gave reasonably good control but its performance was in general inferior to that at centres (a) and (b). Dicamba was also less efficient in this trial, though many of the fronds showed distortion and chlorosis.

Table 2

Effect of different concentrations of picloram and dicamba on bracken fern assessed fourteen months after application

Herbicide	Rate per acre lbs (a.i.)	% control centre (a) Pre-emergence	centre (b) At-emergence	centre (c) Post-emergence
1) Picloram	1.25	96	56	42
2) Picloram	2.4	94	81	68
3) Picloram	3.3	98	86	76
4) Dicamba	4.0	62	55	20
5) Dicamba	6.0	84	75	44
6) Dicamba	8.0	90	86	45
7) Untreated	-	-	-	-

Table 2 shows the state of bracken control fourteen months after application. From this it is evident that the overall control at (a) remained excellent. There was a certain amount of regrowth in the lower treatment of dicamba, but control was nonetheless satisfactory.

At centre (b) there was a considerable amount of regeneration particularly at the lowest picloram treatment. However all the fronds present showed a marked reduction in height. The other treatments all gave fairly similar results.

The greatest regeneration of bracken occurred with post-frond emergence treatments,centre (c). This was greatest at the lowest level of picloram and in the dicamba treatments. However all treatments showed some effect on the bracken.

All the untreated control plots in these trials had a very dense stand of bracken ranging from three to four feet in height.

It was noticed that the bracken in the paths surrounding the treated plot boundaries showed damage symptoms, indicating a possible movement of both these herbicides along the rhizomes out into the surrounding area. This phenomenon was also noted by Aldhous (1964).

The grass sward, mainly a H. mollis/L. perenne mixture, was not damaged by either herbicide except at the highest rates.

DISCUSSION

These results indicate that both picloram and dicamba will give effective control of bracken for at least two seasons after application. However time of application appears to be of great importance if the maximum control with the lowest possible rate of each herbicide is to be obtained.

The results of the picloram treatments suggest pre-frond emergence is the more reliable method of obtaining long term control. This is in agreement with the findings of Clare (1966) but not with those of Hodgson and Donaldson (1966). However some variation of results could be expected due to the different physical and climatic factors involved.

The lower rates of dicamba appear to give the best results when applied just at frond emergence. However while the initial results seemed promising (Table 1) the subsequent control was not as enduring as the pre-frond emergence treatments (Table 2). The post emergence application did not give complete control but there was a considerable reduction in plant height and vigour as a result of treatment.

At present the cost of treatment per acre on an overall basis could be classed as prohibitive. However, further research using low rates of these herbicides applied at a critical stage of growth, could result in effective economic control. A possible combination of mechanical and chemical methods as suggested by Lawson (1964) may give a commercially acceptable degree of control.

Acknowledgements

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References

(1) ALDHOUS, J.R. (1964) Control of bracken (Pteridium aquilinum (L)) with dicamba Proc. 7th British Weed Control Conference 896-98

(2) CLARE, D.J. (1966) Dow Chemical Co. Personal communication

(3) HODGSON, G.L. (1962) Herbicides on bracken - the influence of the date of application Proc. 6th British Weed Control Conference 397-99

(4) HODGSON, G.L. (1964) Sodium-3,6-dichloromethoxybenzoate for the control of bracken (Pteridium aquilinum (L) Kuhn) Weed Res. 4 1964 16-68

(5) HODGSON, G.L. (1966) and DONALDSON Herbicides on bracken (Pteridium aquilinum (L) Kuhn) : Trials with dicamba and picloram.

(6) LAWSON, H.M. (1964) The control of bracken fern with 4-amino,-3,5,6-trichloropicolinic acid. Proc. 7th British Weed Control Conference 887-90

(7) LHOSTE et al (1964) Control of bracken (Pteridium aquilinum (L)) with 4-amino-3,5,6-trichloropicolinic acid. Proc. 7th British Weed Control Conference 891-95

(8) MITCHELL, B.J. (1966) Agricultural Institute Annual Research Report. Plant Sciences and Crop Husbandry Division 1966. 88

(9) TANSLEY, A.G. (1949) The British Islands and their vegetation. Vol. II. 502-504

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HERBICIDAL CONTROL OF BROAD LEAVED DOCKS IN GRASSLAND IN SOUTH WEST ENGLAND AND WALES

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Summary Results are given of two series of studies on controlling heavy infestations of mature broad leaved docks (mainly *Rumex obtusifolius*, with some *R. crispus*) in established grassland. In the first series (1966/67), asulam, maleic hydrazide, tordon and growth regulator herbicides were applied in the autumn at four centres. Asulam and maleic hydrazide were the most consistent herbicides and reduced dock numbers by over 70 per cent. The remaining herbicides were less effective. In the second series (1967/68) a comparison was made between asulam and maleic hydrazide applied in autumn, spring and combined autumn and spring applications at two centres. Spring and combined autumn and spring applications of these herbicides were the most effective in reducing dock numbers and a very high degree of control was obtained. Asulam and maleic hydrazide had a selective effect on some of the grass species in the swards.

INTRODUCTION

There are some areas on most farms where docks present problems of control. Whether derived from shed seed *in situ* or dispersed by winter rains from ditches, hillsides, woodland areas or by flooding, they are a perennial problem to farmers. The situation is aggravated by the more intensive stocking now almost universally practised, often on land inherently wet and in high rainfall areas. This has led to more treading and poaching of the sward and the bare areas produced provide better surface conditions for the establishment of docks and other weeds. Invasion of swards by broad leaved docks has also followed applications of slurry and farm yard manure as dock seeds can survive after passing through the digestive tract of animals and birds. Eradification of docks is difficult as they are prolific seed producers and can remain viable in the soil for up to 60 years. In addition the dock has a remarkable capacity for vegetative recovery and can produce new shoots from very short pieces of rootstock. Any form of control is unlikely to be fully effective - it will remain a recurring problem. Control by cultural methods is very difficult under the high rainfall conditions of the west and control by growth regulator herbicides (MCPA, 2, 4-D, mecoprop and dicamba) is always variable and very transitory. In an effort to find better means of control and following the work of the Weed Research Organisation, two compounds, asulam and maleic hydrazide, were tested on farms and compared with the growth regulators.

METHOD AND MATERIALS

In 1966/67, dock control trials were laid down at four centres, two in the south west and two in Wales. Treatments were replicated two or three times and applied with a knapsack-type sprayer except at the Devon centre where a Land Rover and spray boom was used. In 1967/68 there were two dock control centres, one in Devon and the other in Cornwall. Treatments were duplicated and applied with a Drake and Fletcher knapsack sprayer. Details of the centres are given in Table 1.

Table 1.

	1966/67				1967/68	
	S.W. Region		Welsh Region		S.W. Region	
	Centre 1	Centre 2	Centre 3	Centre 4	Centre 5	Centre 6
County	Devon	Wiltshire	Monmouth	Monmouth	Cornwall	Devon
Sward type	Old ley	Young ley	Old ley	Young ley	Young ley	Old ley
Pre-spraying dock population (per sq. yd.)	21.2	3.6	1.6	3.6	19.4	7.8
Dates sprayed	30.9.66	16.9.66	7.9.66	19.9.66	18.10.67 4.4.68	13.10.67 29.3.68
Volume	20 gal/ac	20 gal/ac	24 gal/ac	24 gal/ac	20 gal/ac	20 gal/ac
Date assessed	15.8.67	23.8.67	6.4.67	13.4.67	18.6.68	18.6.68

There were in addition four farm demonstration sites for dock control, each approximately ½ acre. These were sprayed with asulam at 1½ lb/acre a.i. in autumn 1967 followed by an additional application of 1 lb/acre at two of the sites in Spring 1968.

The experimental areas were topped over about 2-4 weeks before spraying to provide a uniform recovery growth of herbage and docks. At each centre the docks were counted before and after applying the treatments and were based on 10 or 20 random sq. yd. quadrats per plot. At all centres Rumex obtusifolius was the main dock variety with some Rumex crispus.

RESULTS

Table 2 gives the percentage reduction in dock numbers for the 1966/67 trials. At each of the centres maleic hydrazide and asulam had the most consistent effect in reducing dock numbers, and with the exception of tordon at centre 2, had the greatest control. Maleic hydrazide and asulam reduced dock numbers by over 70 per cent when the results are averaged for all centres. Reductions in dock numbers following these treatments were not so high at centre 1 where there was an exceptionally heavy dock infestation. At this centre a further assessment of the docks was made in May 1968, nearly 18 months after spraying. At the higher rate of asulam and maleic hydrazide the treatment effects persisted but there was an increase of 25 per cent over the earlier counts at the lower rate of these herbicides. Some of the recovery was from old rootstocks and some from young or seedling docks and it was difficult to differentiate between the two forms without digging each plant. There was an almost complete recovery of docks following the growth regulator herbicides (dicamba, mecoprop, 2, 4-D/MCPA) and tordon i.e. counts were comparable with those from pre-spraying.

Results for the 1967/68 trials are presented in Table 3. The dock population at centre 5 was much greater than at centre 6, although the docks were not so large or vigorous. Despite this difference in dock population the herbicides resulted in very large reduction in numbers at both centres. The mean percentage reduction in dock numbers for the two centres indicate that spring and combined autumn and spring applications of herbicide were the most effective. Of the two herbicides, asulam gave a better control of docks than maleic hydrazide.

Table 2.

Percentage reduction in dock numbers following autumn 1966 application of herbicide

Treatment (per acre)	Per cent reduction in docks			
	S.W. Region		Welsh Region	
	Centre 1	Centre 2	Centre 3	Centre 4
Maleic hydrazide 2 lb a.i.	50	73	90	94
Maleic hydrazide 4 lb a.i.	59	82		
Asulam 1.5 lb a.i.	68	85	72	73
Asulam 3 lb a.i.	77	88		
Tordon 4 oz. a.e.		90		
Tordon 4 oz. a.e. + 2, 4-D 1 lb a.e.	30			
Tordon 8 oz. a.e. + 2, 4-D 1 lb a.e.	43			
Dicamba 4 oz. a.e. + 2, 4-D 1 lb a.e.		26	41	50
Mecoprop 3.2 lb a.e.	30			
Mecoprop 1 lb a.e.			36	26
2, 4-DB/MCPA 28 oz. a.e.			47	34

Reduction in dock numbers at the farm demonstration sites is presented in Table 4. There is considerable variation in the effectiveness of the herbicides at the four sites.

No quantitative assessments were made of the effect of the herbicides on the botanical constituents of the swards which were largely perennial ryegrass/white clover dominant. Observations indicated that asulam and maleic hydrazide reduced the proportion of *Agrostis* sp., *Poa* sp. and *Holcus* sp. in the sward. At centre 5, where Italian ryegrass was present, this species was considerably reduced by asulam and maleic hydrazide. The 3 lb of asulam and 4 lb of maleic hydrazide caused some thinning of perennial ryegrass but the lower rate had little effect. White clover fully recovered after all treatments with asulam and maleic hydrazide. White clover was killed by tordon, dicamba/2, 4-D, mecoprop at the 3.2 lb rate and severely reduced by mecoprop at the 1 lb rate.

Table 3.

Number of docks and percentage reduction in numbers on 18.6.68

Herbicide	lb. a.i./ac		No. of docks in 10 sq.yd.				Per cent reduction in docks		
			Pre-spraying		Post-spraying				
	Autumn 1967	Spring 1968	Centre 5	Centre 6	Centre 5	Centre 6	Centre 5	Centre 6	Mean
Asulam	1.5	-	177	81	50	17	72	79	75
	-	1.5	151	50	2	0.5	99	99	99
	1.5	0.75	192	102	6.5	20	97	80	88
	0.75	0.75	164	72	13	28	92	61	75
	0.75	1.5	180	58	4.5	18	98	69	83
Maleic hydrazide	2	-	202	88	85	40	58	55	56
	2	1	165	76	39	14	76	82	79
	1	1	177	49	46	10.5	74	78	76
Control			184	78					

Table 4.

Number of docks and percentage reduction on 15.6.68 following asulam at $1\frac{1}{2}$ lb a.i. per acre in autumn 1967 and 1 lb in spring 1968

Centre	Date sprayed		No. of docks in 10 sq.yd.		Per cent reduction
	Autumn	Spring	Pre-spraying	Post-spraying	
Dobwalls, Cornwall	18 Nov.	25 April	148	29	80
Herodsfoot, Cornwall	18 Nov.	Not sprayed	77	30	61
Pinhoe, Devon	23 Oct.	Not sprayed	95	9	91
Ashprington, Devon	23 Oct.	1 May	71	19	73

DISCUSSION

A high degree of control of docks in grassland was obtained at all centres using asulam and maleic hydrazide. The effect was not diminished even when the dock population was in excess of 20 per sq.yd. Results from the first series of trials (Table 2) suggested that the $1\frac{1}{2}$ lb rate of asulam and 2 lb. of maleic hydrazide were almost as effective as double this rate. Subsequent dock assessments at the Devon centre in June 1968 (nearly 18 months after spraying) showed that whilst the heavier rates of these herbicides gave a very high degree of dock kill, there was a 25 per cent recovery at the lower rates. This suggests that the optimum rate of application to achieve permanent control could be between $1\frac{1}{2}$ and 3 lb of asulam and between 2 and 4 lb of maleic hydrazide. The old docks that recovered at the Devon centre had massive and entwined roots and sent out fresh shoots from the periphery of the blackened and decayed crown. Docks with smaller root systems rarely survived the treatments. The growth regulator herbicides were far less effective in reducing the dock population and there was a high recovery. They had the added disadvantage of killing or severely reducing the clover content of the sward.

In the second series of trials (Table 3) an attempt to define more precisely the optimum rate and time of application of asulam and maleic hydrazide was not entirely conclusive. The spring and combined autumn and spring applications of herbicides were the most effective; the spring application of asulam was the more consistent in reducing dock numbers. In the design of the experiment, however, the combined autumn and spring treatment plots were sprayed in spring to co-incide with a good growth of dock foliage on the spring only treatment plots. At this time there was little recovery of docks from the autumn treatment. Deferring the spring application of the combined dressing to co-incide with maximum dock recovery might have given more effective control. The timing of the spring application may be very critical in determining the effectiveness of a combined autumn and spring dressing. Further work is required in this field.

Both asulam and maleic hydrazide cause considerable chlorosis of grass leaf tissue, reducing the amounts of Agrostis and Poa sp. and hence some loss of production. This selective effect of asulam on the constituents of the sward has been reported by Ford and Combellack (1966). Autumn treatments, applied in late September/October when growth has almost ceased, will have a smaller effect on overall grass production than spring applications. These herbicides applied during peak grass growth and when in greatest demand by livestock may seriously impair output by lowering sward density and delaying growth. Under farm conditions, it would appear more practical to apply the higher dose of the herbicide in the autumn and to follow this with a small additional dose of the herbicide in spring/early summer where there is any marked recovery of docks.

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References

Ford, R. T. G. and Combellack, J. H. (1966). The use of asulam for the control of docks in pasture. Proc. 8th Brit. Weed Control Conf., 355-359.

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ASULAM FOR THE CONTROL OF DOCKS IN GRASSLAND

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Summary Development work with asulam (methyl 4-aminobenzenesulphonylcarbamate) against docks *Rumex obtusifolius* and *R. crispus* has continued since 1965.

Pot experiments have shown that maximum herbicidal activity is obtained at a spray volume of 10 to 20 gals/acre. Asulam acts by killing the plant meristems. For good control, uptake by the mature expanded leaves is essential; uptake through the soil or by the dock crown is relatively unimportant.

Experiments organized on an extensive scale have established that a dose of 1 lb a.i. per acre gives reliable field results with minimal harm to pasture grasses. It was essential for a period of active vegetative growth to follow spraying, hence in practice the best treatment times were spring or late summer.

INTRODUCTION

The early field work with asulam demonstrated its activity against docks infesting pastures and orchards, Ford & Combellack (1966). Extensive trials in 1966/67 showed that a single spring application at 1 to 2 lb/acre controlled moderate infestations of docks and that dual spring and autumn applications at 1 + 1 or 2 + 2 lb/acre controlled heavy populations. The further series of experiments reported here were carried out in 1967/68 to confirm the dose and timing necessary to give control of well-established broad-leaved and curled docks without damage to pasture, and also to verify the activity of asulam when applied by users under a wide variety of practical conditions.

METHOD

Two outdoor pot experiments were carried out using 6-8 leaf *R. obtusifolius* plants, with six replicates in randomised blocks. Plants were sprayed with asulam 75% K salt at ½, 1, 2 and 4 lbs/acre a.i., at 10, 20 and 40 gals/acre, using the laboratory sprayer. The first experiment compared volume rates of application with and without wetter,and the second the effects of shielding the soil or portions of the plants from the spray. Plants were sprayed in September, 1967 and final mortalities were assessed in May, 1968.

The field work consisted of three series of experiments against docks which were begun in the autumn of 1967 and herbage yield and tolerance trials which were set up in spring 1968. The 40% w/v aqueous concentrate formulation of asulam, as the sodium salt, was used in all but the tolerance experiments where the 75% K salt was applied.

At two replicated sites on dock-infested pastures asulam was applied at $1\frac{1}{2}$ lb and 1 lb per acre at three different times both in the autumn and spring as a single treatment. Application was made with the small-plot sprayer at a volume rate of 20 gallons per acre. Prior to the first autumn treatment the docks were allowed to develop mature leaves, and 'normal' management of the pastures was resumed two to three weeks after the final spring application. At a further twenty pasture sites, asulam was applied at 2 lb and 1 lb per acre in the autumn and cross-sprayed with 1 lb and $1\frac{1}{2}$ lb per acre in the spring, leaving a control strip on each occasion. This work was carried out with the Land-rover mounted sprayer, again at 20 gallons per acre, without replication. There was minimal interference with the farmer's normal grassland management policy. Parallel to this work user trials were organised with the co-operation of more than 80 farmers who applied a single spring treatment of $1\frac{1}{2}$ lb asulam per acre or a combined autumn plus spring treatment of $1\frac{1}{2}$ plus 1 lb per acre according to the severity of the initial dock infestation.

In the case of the replicated trials, dock assessments pre- and post-spray were carried out by recording the number of shoots present in two fixed quadrats (5' x 2' 6") per plot. In the non-replicated (Land-rover and farmer-applied) trials a diagonal transect method was used post-treatment: the number of dock plants in two diagonal bands each 25 yds long by 2 yds wide were counted on treated and untreated areas.

In the yield experiments three different leys, virtually free of docks and with only a low level of broad-leaved weeds, were treated with 1, $1\frac{1}{2}$ and 3 lb of asulam per acre in May. Two sites were 'topped' one week before and the third site (Fyfield) three weeks before treatment. Herbage yields from the five replicates were taken at suitable intervals for up to 12 weeks after application. In the tolerance experiments ten different pasture grasses and two clover species were sown down in May 1967 in three replicate blocks for cross-treatment with asulam. A dose of $1\frac{1}{2}$, 2, or 3 lb per acre was applied in the subsequent autumn and the visual appearance of the grasses and clovers was assessed at intervals ranging from one to nine months after treatment.

RESULTS and DISCUSSION

Table 1.

Effect of spraying at different volumes with and without wetter

Number of dead dock plants out of 6, 8 months after applying $\frac{1}{2}$ lb asulam/acre

Gallons/acre	No wetter	Ethylan CP 0.05%	Pentrone T 0.05%
10	5	3	2
20	3	4	3
40	1	0	1

Table 2.

Effect of shielding on dock mortality

Number of dead dock plants out of 6, 8 months after application
(Vol. 20 gal/acre, without wetter)

Treatment	lb. asulam/acre			
	0.5	1	2	4
Unshielded control	3	6	6	6
Mature leaves shielded	0	0	0	0
Growing point shielded	5	6	6	6
Whole plant sprayed (soil shielded)	3	6	6	6
Soil application (plant shielded)	0	0	0	0

Table 3.

Effect of single treatments of asulam applied at three different times in autumn 1967 and the subsequent spring

% reduction in dock shoots over a 12-month period (total of three reps. per treatment)

Treatment and Timing	Dose: 1 lb a.i./acre				Dose: $1\frac{1}{2}$ lb a.i./acre			
	No. of dock shoots per 10 sq yds September 1967		% reduction of dock shoots by September 1968		No. of dock shoots per 10 sq yds September 1967		% reduction of dock shoots by September 68	
	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B
Autumn 1967:								
18-22nd Sept	200	45	32	+71*	207	38	26	+59*
9-12th Oct	138	56	39	+26*	138	31	43	+35*
30th Oct-2nd Nov	135	46	+12*	+90*	161	51	+ 2*	+70*
Spring 1968:								
18-22nd March	167	57	19	+23*	152	40	42	+38*
8-11th April	174	36	66	70	155	52	81	86
29th April-2nd May	100	23	75	100	124	55	91	85
Control	202	62	14	+85*	124	21	+50*	+83*

*This represents a percentage increase
Site A - Broadwindsor
Site B - Kilmington

Table 4.

Control of dock plants 2 to 4 months after spring treatment (8 to 10 months after autumn treatment) with asulam

Total of 19 'Land Rover' sprayed unreplicated sites

Treatment regime lb asulam/acre		Mean No. of dock plants per 100 yd^2	% control of dock nos. of unsprayed population	No. of sites giving stated % reduction in dock numbers		
late Sept-early Nov. 1967	late March-early May 1968			76-100%	60-75%	60%
1	-	252	26	3	4	12
2	-	289	15	3	5	11
1	1	94	72	11	5	3
1	$1\frac{1}{2}$	67	80	12	2	5
2	1	88	74	12	3	4
2	$1\frac{1}{2}$	55	84	13	3	3
-	1	154	55	7	6	6
-	$1\frac{1}{2}$	72	79	10	5	4
Control		340	-	-	-	-

Table 5.

Control of dock plant 2 to 4 months after spring treatment (9 to 10 months after autumn treatment) with asulam

Total of 51 farmer-applied unreplicated sites

Dose of asulam lb/acre or conc.		Method of application	No. of sites giving stated % reduction in dock numbers			
Late Oct.-Nov. 1967	Late March-May 1968		90-100%	76-89%	60-75%	60%
1½	1	L.V Ground-crop Sprayer	7	1	2	4
1 in 200	1 in 200	Knapsack	0	2	1	1
-	1½	L.V Ground-crop Sprayer	7	5	10	4
-	1 in 200	Knapsack	2	2	1	2

Table 6.

Tolerance of established grasses and clovers to asulam

Visual appearance score: 0 = no damage to
5 = complete kill (mean of
3 reps., 2 observers/rep.)

Date of sowing: May 1967 Date of application: 24th October, 1967

Asulam lb a.i/acre	Interval (months) between application and assessment	Per. Ryegrass S24	Per. Ryegrass S23	It. Ryegrass S22	Timothy S48	Meadow Fescue S215	Cocksfoot S37	Red Clover S123	White Clover S100	R. Stalked Meadow grass	Yorkshire Fog	Red Fescue	Annual Meadow Grass
1½	3	2.2	1.7	0.8	1.7	2.0	2.5	1.5	0.7	3.7	3.7	1.3	2.5
	9	0	0	0	0	0	0	0	0	0	0	0	-
2	3	2.2	2.7	1.7	2.3	2.3	2.7	1.5	0.8	4.2	3.7	1.8	3.3
	9	0	0	0	0	0	0	0	0	0.7	0.5	0	-
3	3	3.2	2.8	1.7	2.8	3.0	2.3	1.8	1.5	4.0	3.3	1.8	4.0
	9	0	0	0	0	0	0	0	0	0	2.8	0	-

Table 7.

Effect of asulam on herbage yield

Yield of dry matter (tons/acre) as percentage of control (Mean of 5 replicates)
Date of application: 12.6.68 - Fyfield, 17.5.68 - Ongar sites

Interval between spraying and cutting	Asulam lb/ac	H.R.S. Ongar: Timothy/Meadow Fescue/ Per. Ryegrass White clover sward	High Ongar: Timothy/Cocksfoot/ Per. Ryegrass sward with clovers & fescues	Fyfield: Creeping Bent/ Red Fescue/Cocksfoot Y. Fog pasture
3 weeks	1	68 b	81 b	93 a b
	1½	58 b	74 b c	93 a b
	3	58 b	68 c	81 b
	0	100 (=0.9 tons/ac) a	100 (=0.52 tons/ac) a	100 (=1.75 tons/ac) a
6 weeks	1	75 b	54 b	110 a
	1½	66 b	41 c	106 a
	3	32 c	24 d	72 b
	0	100 (=0.41 tons/ac) a	100 (=0.89 tons/ac) a	100 (=0.17 tons/ac) a b
9 weeks	1	107 a	134 b	81 b
	1½	102 a	128 b	83 b
	3	82 b	93 a	54 c
	0	100 (=0.45 tons/ac) a	100 (=0.13 tons/ac) a	100 (=0.27 tons/ac) a
12 weeks	1	-	-	94 a
	1½	-	-	79 a
	3	-	-	69 b
	0	-	-	100 (=0.28 tons/ac) a

Duncan's Range Test: Any two figures with a common suffix a, b, or c are not significantly different from one another at the 5% level.

Effect of timing

A recent assessment of the percentage control of dock shoots following single applications of asulam made at different times in the autumn and spring is given in Table 3. The best treatments were single April doses at 1 or 1½ lb a.i. per acre, and the poorest treatments the single autumn doses, particularly when applied late. This may be due in part to the different time intervals that have elapsed between the respective treatment and assessment dates.

In the user trials the results of the dual programme of 1 lb of asulam per acre in the autumn followed by 1½ lb acre in the spring were more variable than the single spring treatment of 1½ lb per acre (Table 5). This was probably due to the general lateness of the autumn treatments - sometimes these extended into November - which meant that spring development of dock leaves was retarded and hence the subsequent spray was not applied at the ideal time either. In the Land-Rover sprayed trials, much better results were achieved with the dual treatments, which were more reliable than the single autumn doses or single spring dose of 1 lb per acre (Table 4). Clearly, at severely infested sites a second treatment was valuable for controlling docks shielded from the earlier application. Even better results might have been achieved by commencing control measures with a single spring treatment, followed by an application in the subsequent autumn or spring.

The shielding experiment showed clearly that applying asulam to the soil or to the growing point had only very little effect on the plants (Table 2). Virtually all the herbicidal effect was contributed by the spray falling on the mature dock leaves.

For the best control of established docks with asulam it therefore seems important for the plants to be treated at the fully-expanded leaf stage while actively growing, and for a short period of active growth to ensue after application, before winter dormancy or defoliation by grazing or cutting takes place. Application during late flowering or seeding has given indifferent control, but treatment at flower initiation is normally satisfactory. Treatment in the dormant period (November to February) is unsuccessful.

Effect of Dose, Volume and Wetter

In pot experiments nearly all the mature plants sprayed at 1 lb per acre (or more) were killed at all volume rates, but at the ½ lb per acre dose there was a clear reduction in herbicidal effect at 40 gals per acre (Table 1). This result was backed by spray retention studies, which showed that less herbicide was retained by dock plants at 40 gal/ac. than at 20 or 30 gal/ac. It is also interesting to note that in the user trials (Table 5), application by Knapsack Sprayer (60 to 80 gal/ac.) was less reliable than comparable treatments applied by ground-crop sprayers. The addition of a wetting agent did not increase dock mortality.

Effect on pasture

Tolerance tests have shown that established pure stands of S100 white clover or S22 Italian ryegrass are practically unaffected by 1½ lb asulam per acre. At this dose some yellowing is caused to perennial ryegrass (strains 23 and 24) red fescue, and S123 red clover, but this effect quickly disappears. Yorkshire fog, rough-stalked meadow grass and annual meadow grass are the least well-tolerated species, but even then damage is not permanent unless the dose is raised to 2½ to 3 lb/acre. The tolerance of timothy grass, meadow fescue and cocksfoot is intermediate between Yorkshire fog and perennial ryegrass.

In the absence of broad-leaved weed cover a moderate reduction in herbage yield was caused by a spring application of 1 lb of asulam per acre, with a slightly worse effect at 1½ lb (Table 7). However, there was a complete recovery to normal yield by nine weeks after treatment except at the one site containing a high proportion of susceptible grasses.

CONCLUSIONS

There is no doubt that, provided application is made at the correct growth stage, asulam at 1 to 1½ lb per acre is active against established docks, but the success of field treatments will very much depend on the method of grassland management before and after spraying. Further studies are needed on the reasons for the survival or regrowth of some treated plants and on how to prevent re-infestation by seedlings, which can quickly mature. Further work is also needed on the benefit to the farmer of dock removal, the influence of pasture competition, and the ecology and life-cycle of the broad-leaved dock.

ACKNOWLEDGEMENTS

We should like to acknowledge the assistance given by many of our colleagues and to express our gratitude for the trial facilities given to us by many farmers.

REFERENCES

FORD, R. T. G. and COMBELLACK, J. H. (1966). The use of asulam for the control of docks in pasture. Proce. 8th Brit. Weed Control Conf. 1 355-9.

Proc. 9th Brit. Weed Control Conf. (1968)

THE CONTROL OF RUMEX OBTUSIFOLIUS BY SULPHONYL CARBAMATE HERBICIDES

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Summary (Methyl N-(4-nitrobenzenesulphonyl)carbamate) (M&B 8882) and asulam both at 4 lb a.i./ac gave better control of *Rumex obtusifolius* in a specially planted pure stand when applied in September than in May. March and August applications of M&B 8882 at 4 lb a.i./ac gave very good control but application in November was much less effective. M&B 8882 applied in July at 2 lb a.i./ac gave reasonable control of *R. obtusifolius* in a perennial ryegrass pasture. The addition of maleic hydrazide improved control at one level of dose but not at another. Control from November applications was inferior; asulam at 2 lb a.i./ac gave a little better control than M&B 8882 at the same dose. The addition of maleic hydrazide to asulam or M&B 8882 in November did not assist control of the weed materially, and caused damage to the ryegrass.

INTRODUCTION

Rumex obtusifolius is a prevalent weed of grassland and has been recorded in all British and Irish vice counties (Cavers and Harper 1964). Work has been carried out at Begbroke for several years on specially planted pure stands of *R. obtusifolius* (Anon. 1967) and the present paper reports some of the results obtained with the sulphonyl carbamate herbicides. A later experiment investigated in the pasture situation promising treatments indicated by this earlier work. Of these, asulam for control of docks has already been reported on by Ford and Combellack (1966). The related herbicide M&B 8882 was compared with asulam because it is less damaging to any clover present in the sward. Maleic hydrazide was also thought to be effective on docks with little risk to clover.

METHOD AND MATERIALS

The experimental site at Begbroke had been established using plants which had been specially raised from seed sown in pots in April 1963. Four or five seedlings were planted in each square yard field plot in July 1963. Management of the area was aimed at maintaining the original stand and preventing seeding. Thus immediately after flowering but before seed formation the tops were cut down to about 4 in. in height.

Treatments were applied using a single nozzle sprayer designed for treatment of small areas. After the application on 2.8.66 the nozzle was changed from an Allman 0 applying 100 gal/ac to an Allman 0000 applying 50 gal/ac. In both cases a working pressure of 30 lb/in^2 was used. Assessment was by a scoring system for vigour in which 0 = complete kill and 10 = as control.

The pasture site was an S23 perennial ryegrass sward with a severe infestation of docks, mainly *R. obtusifolius*. This pasture had been sown in April 1964 and managed intensively since on a paddock grazing system with a 15-16 day cycle between March and November: 350-400 units of nitrogen and 40-50 units of potash and phosphate had been applied annually. The field had never been cut for hay but was topped about three times during each season.

Treatments applied were a) on July 12th 1967:
M&B 8882 at 0.5, 1.0, 2.0 lb a.i./ac
M&B 8882 + maleic hydrazide at 0.5 + 0.5, 1.0 + 1.0, 2.0 + 2.0 lb a.i./ac

b) on November 10th 1967:
M&B 8882 at 0.5, 1.0, 2.0 lb a.i./ac
asulam at 0.5, 1.0, 2.0 lb a.i./ac
M&B 8882 + maleic hydrazide at 0.5 + 0.5, 1.0 + 1.0, 2.0 + 2.0 lb a.i./ac
asulam + maleic hydrazide at 0.5 + 0.5, 1.0 + 1.0, 2.0 + 2.0 lb a.i./ac

M&B 8882 and asulam were formulated as water soluble powders of the potassium salt and maleic hydrazide as an aqueous concentrate of the diethanolamine salt.

Treatments were applied with the Oxford Precision Sprayer using 8002 Teejets delivering 20 gal/ac at 30 lb/in^2. At the time of spraying in July the S23 pasture was 9-12 in. high and most of the Rumex plants were of a similar height with a good leaf area exposed. In November the ryegrass was about 5-6 in. in height but with a few bare patches: the docks were small, about 3-4 in. high with only a small leaf area exposed. Plot size was 2 x 6 yd. Treatments were replicated twice in randomised blocks. The total number of dock plants were counted on each plot immediately pre-spraying and then at intervals thereafter. There was heavy overnight rain on 13th July when 0.5 in. rain fell and conditions were generally overcast: very little rain fell after the November application and there was no frost for a week afterwards.

RESULTS

Figure 1 displays the assessments made at intervals after spraying showing the effects of asulam and M&B 8882 applied at different times to the pure dock stand. The data in tables 1 and 2 show counts of plants surviving treatment in the pasture experiment, as indicated by the presence of above ground foliage.

Table 1

Effect of treatment in July on R. obtusifolius in pasture

Total plant count per plot: count as percentage of pre-spraying number, in brackets

	At spraying	+5 wks	+8 wks	+41 wks	+50 wks
Untreated control mean	69	52(76)	48(70)	87(127)	83(120)
M&B 8882 at 0.5 lb a.i./ac	91	32(36)	23(25)	51 (56)	71 (77)
1.0	98	40(41)	7 (7)	46 (47)	69 (70)
2.0	72	33(46)	2 (3)	9 (12)	18 (24)
M&B 8882 + maleic hydrazide					
at 0.5 + 0.5 lb a.i./ac	71	34(48)	18(25)	59 (82)	70 (98)
1.0 + 1.0	73	28(39)	2 (3)	16 (21)	29 (40)
2.0 + 2.0	79	32(40)	3 (4)	17 (21)	25 (32)

Table 2

Effect of treatment in November on R. obtusifolius in pasture

Total plant count per plot: count as percentage of pre-spraying number, in brackets

	At spraying	+23 wks	+32 wks
Untreated control mean	55	77(141)	53 (97)
M&B 8882 at 0.5 lb a.i./ac	42	54(129)	38 (91)
1.0	61	67(110)	39 (65)
2.0	60	67(113)	41 (68)
Asulam at 0.5 lb a.i./ac	68	96(142)	61 (90)
1.0	62	82(132)	45 (72)
2.0	58	55 (95)	29 (49)
M&B 8882 + maleic hydrazide at 0.5 + 0.5 lb a.i./ac	62	73(119)	56 (90)
1.0 + 1.0	46	65(143)	44 (97)
2.0 + 2.0	39	45(115)	44(112)
Asulam + maleic hydrazide at 0.5 + 0.5 lb a.i./ac	61	68(112)	45 (73)
1.0 + 1.0	51	53(104)	47 (91)
2.0 + 2.0	49	31 (63)	26 (54)

DISCUSSION

The data in Fig. 1 illustrate the variation in effect with time of application as the plants age. The ten week old plants at the first application were most susceptible to asulam at 4 lb a.i./ac and subsequently September applications were more effective than treatments in May. M&B 8882 and asulam can be compared at only one date and at that time (May 1965) asulam had more effect than M&B 8882. The changeover to M&B 8882 in the experiment was made as other information became available to suggest this herbicide was less damaging to clover. Applied both in August and in March very good control was given by 4 lb a.i./ac M&B 8882, but after the November application early recovery occurred. Thus the preliminary experiments indicated that these herbicides would be worth investigating for dock control in grassland.

In the pasture situation treatments applied in July were more effective in controlling R. obtusifolius than were those in November.

Applied in July, 2 lb a.i./ac M&B 8882 gave reasonable control and although some recovery was apparent there was still a 75% reduction 50 weeks after spraying. Regrowth of docks treated with 1 lb a.i./ac was much quicker. A mixture of maleic hydrazide + M&B 8882 at 2 + 2 lb a.i./ac did not give better control than 2 lb a.i./ac M&B 8882 alone. It did seem, however, that 1 + 1 lb a.i./ac maleic hydrazide + M&B 8882 delayed recovery much longer than 1 lb a.i./ac M&B 8882 alone. The increase in docks between 41 and 50 weeks on treated plots was due to re-appearance of leaves from underground portions of root still surviving.

In November, mixtures with maleic hydrazide proved much too damaging to the ryegrass and were not suitable for use at that time of year; it should be noted that control of docks by these mixtures was no better than with either M&B 8882 or asulam alone. Asulam at 2 lb a.i./ac was more effective than M&B 8882 at a similar dose but even so, after 32 weeks there was only a 50% reduction in number by the asulam treatment. The plots treated in November were unfortunately cut about three weeks prior to spraying and as regrowth is slow at that time of year the dock plants were very

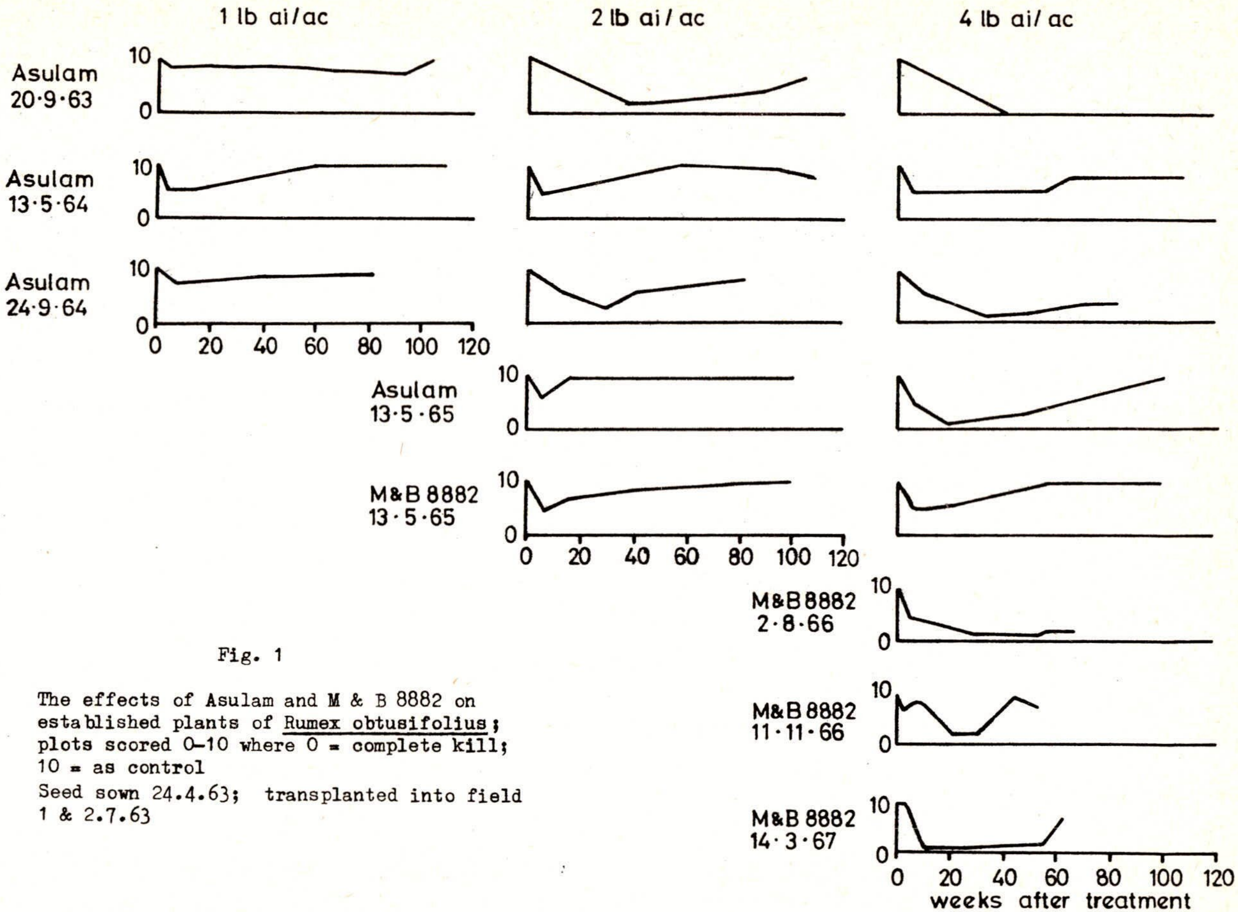

Fig. 1

The effects of Asulam and M & B 8882 on established plants of <u>Rumex obtusifolius</u>; plots scored 0–10 where 0 = complete kill; 10 = as control

Seed sown 24.4.63; transplanted into field 1 & 2.7.63

small above ground and only a minimum of leaf area was exposed. This result confirms the earlier finding (Fig. 1) that a November application was not very effective.

The experiments under discussion demonstrate the useful effects of asulam & M&B 8882 for control of R. obtusifolius. However the results may be unsatisfactory if application is delaved until late autumn. Repeat application might be necessary in some circumstances to produce complete control; the addition of maleic hydrazide to the original spray does not provide the necessary improvement in control.

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References

ANONYMOUS (1967) Weed Research Organisation Second Report 1965-1966, 14-15.

CAVERS, P. B. and HARPER, J. L. (1964) Biological Flora of the British Isles No. 98 Rumex obtusifolius L. and R. crispus L. J. Ecol. 52, 737-766.

FORD, R. T. G. and COMBELLACK, J. H. (1966) The use of Asulam for the control of Docks in Pasture. Proceedings of 8th British Weed Control Conference 1, 355-359.

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PRELIMINARY REPORT OF STUDIES ON POA TRIVIALIS (ROUGH-STALKED MEADOW GRASS) IN GRASS SEED CROP

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Summary *Poa trivialis* is a problem in grass seed production both in the field and in seed cleaning. Studies on the following are reported:

1. A method of assessing the contamination of grass seed crops by *Poa trivialis* and the results obtained in ten crops. The effect of such weed competition is also estimated.

2. A comparison between the numbers of seeds of some weeds in grass seed as harvested, with the numbers of such seeds after cleaning, as a measure of the difficulty in cleaning weed seeds out of grass seed. The particular problems with *Poa trivialis* are discussed.

3. The flame treatment of grass seed contaminated with *Poa trivialis* to prevent clustering of its seeds, to facilitate cleaning without damaging the crop seed.

INTRODUCTION

Ten grass seed crops of the following species were visited immediately prior to harvest in 1967:

Perennial ryegrass	- 4 crops	Meadow fescue	- 2 crops
Cocksfoot	- 3 crops	Timothy	- 1 crop

Representative samples were taken from each and the level of contamination assessed by comparing the number of weed heads with the number of crop heads in a unit area. An attempt was also made to determine the potential reduction in yield when contaminated with *Poa trivialis.*

Thirty other samples of uncleaned (as harvested) seed were compared with the same seed after cleaning to determine which weeds were difficult to remove, particular attention being paid to *Poa trivialis.*

A report by Klein, M.K. *et al* (1961) has shown that "debearding" of pure samples of naturally hairy seeds, as a prerequisite to sowing, can be successfully undertaken by flame treatment. Tests were made to see whether in grass seed contaminated with *Poa trivialis*, the basal hairs of the latter could be burnt away by flame treating the seed mixture to facilitate cleaning without detriment to the crop seed.

METHOD AND MATERIALS

In each of the ten crops samples were taken from 20 areas following a W shaped path within the field. On each leg of the W, five samples, which included both crop and *Poa trivialis* heads, were taken. In narrow row crops, such as the ryegrasses each sampling area measured 3 $ft.^2$ In crops grown in 14 inch or wider rows, a measured 3 ft. length of row together with the inter-row space was taken. The samples were sorted in the laboratory and counted into crop and weed heads.

Samples of uncleaned seed were drawn from crops harvested in 1964 to produce British Certified Seed and were taken from bulks before and after cleaning in commercial seed establishments. Counts were made on thirty, 150-200 g. samples of uncleaned seed of each of the varieties S.24 perennial ryegrass, S.143 cocksfoot and S.51 timothy. The results for cleaned seed were from the purity analyses on 2-5 g. samples and were obtained by the Official Seed Testing Station, Cambridge.

Flame treatment tests were made on:

A. A homogeneous mixture consisting of 85% of S.215 meadow fescue and 15% by weight of freshly harvested Poa trivialis seed. This corresponds closely with some seed harvested in 1967.

B. Pure seed samples of S.22 Italian ryegrass, S.24 perennial ryegrass, S.143 cocksfoot and S.59 meadow fescue.

The prepared material was processed in the apparatus shown in Figure 1, the propane paint stripper burner constantly operating at 30 lbs./in.^{2} Equal quantities of treated and untreated seed were then cleaned in a box consisting of sieves shaken mechanically for 30 seconds.

Homogeneous samples of treated and untreated cleaned seed were then sent to the Official Seed Testing Station, Cambridge for purity analyses to determine the number of Poa trivialis seeds remaining within the crop seed after cleaning. A germination test on each was also undertaken.

The treated seed samples referred to in B. were tested only for germination.

RESULTS

Figure 1 shows the experimental apparatus for treating grass seed.

Table 1 shows an examination of the contamination levels of Poa trivialis in ten crops, as measured by numbers of heads per yd.^{2}

Figure 2 and Table 2 show the results from a crop of S.215 meadow fescue when plotted on a graph, an attempt being made to estimate the reduction in crop yield (in terms of seed weight and gross returns per acre) caused by weed competition.

Figure 3 shows an examination of 30 uncleaned and cleaned samples.

Tables 3 and 4 show the effect of flame treatment on the cleaning and germination of grass seed.

Figure 1

Experimental apparatus for treatment of grass seed

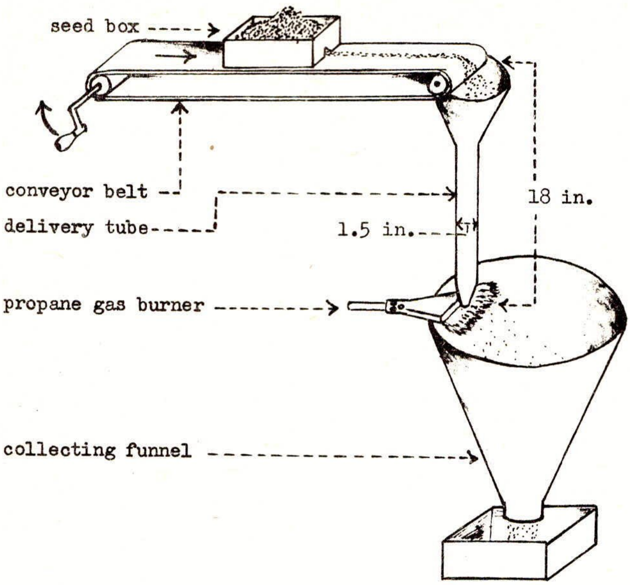


Table 1

Mean numbers of heads in grass seed crops sampled

Crop variety and species	No. of crop heads per yd.^{2}	No. of Poa trivialis heads per yd.^{2}	Ratio of weed heads to crop heads
Perennial ryegrass			
S. 24	1,388	928	1:0.7
S. 23	1,517	329	1:0.2
S. 23	1,252	3	1:0.003
S.321	2,510	77	1:0.03
Cocksfoot			
S.345	383	503	1:1.3
S. 37	356	78	1:0.2
S.143	425	5	1:0.01
Meadow fescue			
S.215	678	1,372	1:2.03
S.215	681	287	1:0.3
Timothy			
S. 48	202	573	1:2.8

Figure 2

Competitive effect of (Poa trivialis) on S.215 Meadow Fescue

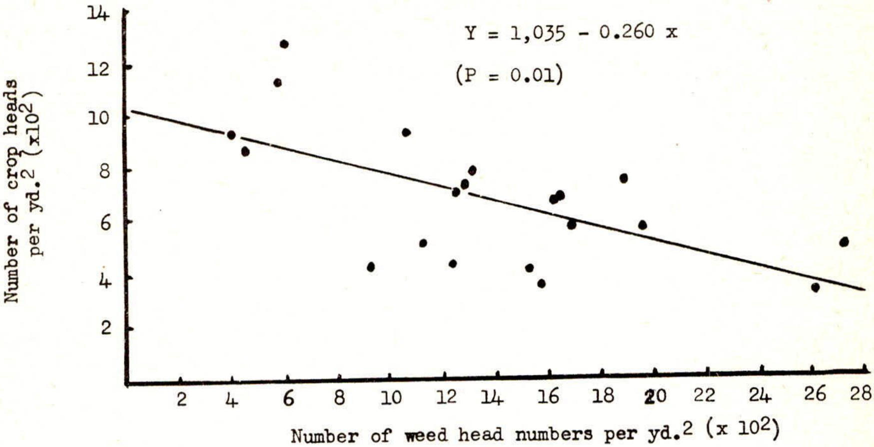


Table 2

Estimate of the reduction of S.215 meadow fescue by Poa trivialis contamination

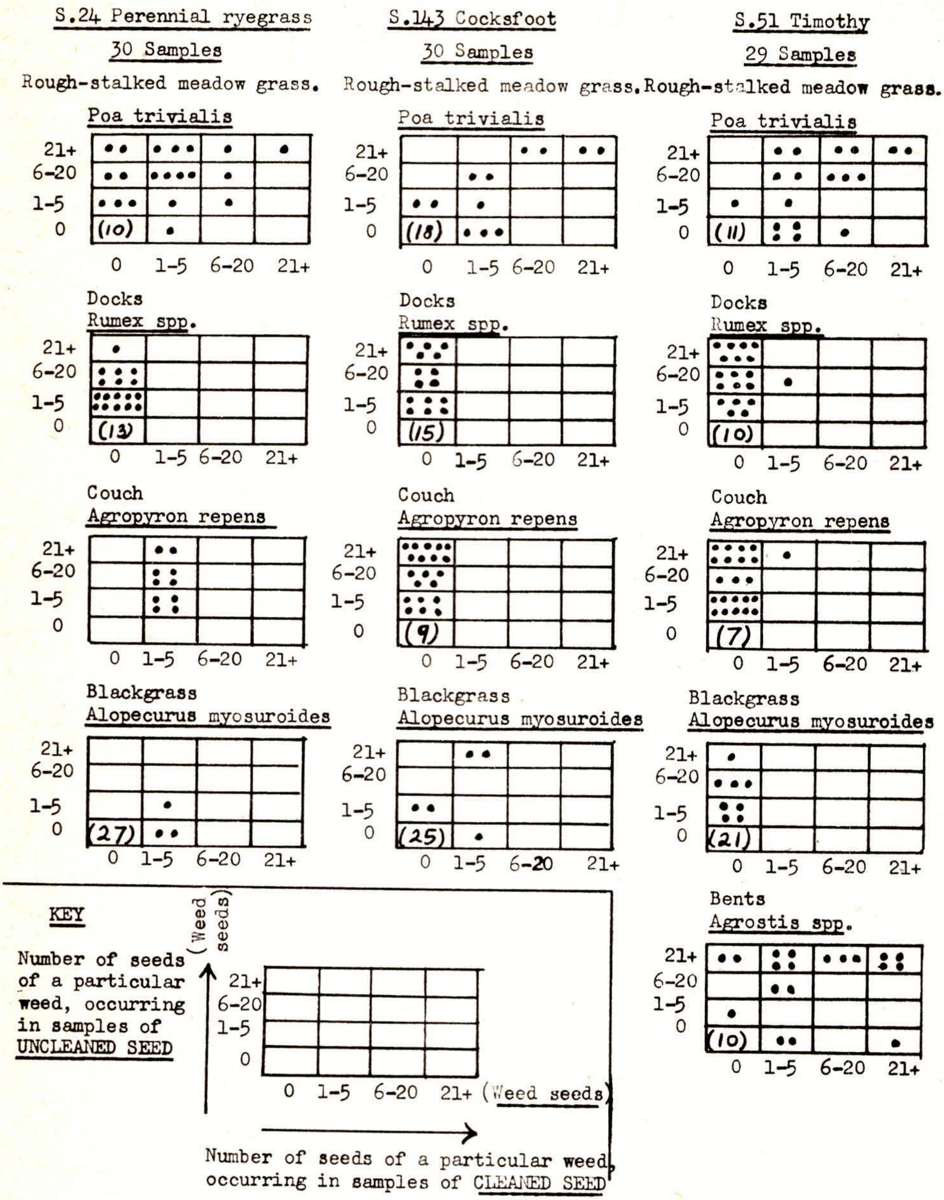
	No. of heads of Poa trivialis per yd.^{2}	No. of crop heads per yd.^{2}	Yield of cleaned seed of crop per acre	Gross return per acre (1967 prices)
Actual mean results recorded	1,372	678	419 lb.	£36 13s. 3d.
Highest estimate of potential crop	0	1,035 (see graph)	641 lb.*	£56 1s. 9d.
Loss due to Poa trivialis	0	357	221 lb.	£19 3s. 6d.

*The estimation of the yield of crop seed per acre was calculated:

$$\frac{419}{678} \times \frac{1,035}{1} = 641 \text{ lb.}$$

Figure 3

Number of some common weed seeds contaminating uncleaned and cleaned grass seed



● = 1 sample in which the weed seed was found, at the numbers shown.
() = Figures in brackets denote number of samples in which weed was not found.

Table 3

Purity Analysis and Germination Results of Flame treated seed

	Number of Poa trivialis seeds in a sample of 5.0g.	Germination of crop seed		Germination of Poa trivialis seed	
1. Original mixture (1000g.)	3,375	-		-	
2. Untreated seed after cleaning (500g.)	388	96%	3%*	97%	4%*
3. Treated seed after cleaning (500g.)	12	94%		89%	

Time taken for the mixture of 500g. to pass through flame = 15 min.

Table 4

Species and Variety (60g. samples)	Germination test of Treated Sample	*	Germination test of Untreated Sample
S.143 Cocksfoot	77%	7%*	71%
S. 59 Red fescue	90%	4%*	91%
S. 24 Perennial ryegrass	97%	3%*	98%
S. 22 Italian ryegrass	98%	2%*	99%
S. 48 Timothy	98%	2%*	98%

*Acceptable levels of tolerance according to the International Rules for Seed Testing

DISCUSSION

The results indicate:

(1) The level of contamination by Poa trivialis in each of ten crops

(2) A method by which the amount of Poa trivialis in a seed crop can be measured and an estimate of the crop loss due to the presence of the weed.

Results published by D. J. Griffiths et al (1967) show that S.215 meadow fescue is capable of yielding 1,108 lb. of seed per acre, the highest estimates in Table 2. is 40% below this potential.

Where a crop contains up to 1,000 heads or more per square yard (see Table 1 and 2), the seed production potential of the weed is considerable, preliminary estimates indicate that one head of Poa trivialis is capable of producing 1,500 ripe seeds.

This method of assessing the contamination of a grass seed crop by Poa trivialis is a useful technique for measuring changes which may occur from year to year in a crop which has been subjected to various weed control treatments. It is likely that the method could be extended to certain other weeds.

Figure 3 shows which weeds are difficult to clean out of crop seed. Since the cleaning process is dependent on machinery taking advantage of differences between weed and crop seed in weight, shape and size, where a weed seed closely approaches the crop seed in these characters, then it becomes difficult to clean.

Docks (Rumex spp.) were never found in cleaned samples of perennial ryegrass or cocksfoot and only rarely in timothy. Couch (Agropyron repens) however occurred in a number of the cleaned samples of perennial ryegrass but rarely in cleaned cocksfoot or timothy despite frequent occurrence in the uncleaned seed.

Blackgrass (Alopecurus myosuroides) was no problem in timothy but was found in some cleaned samples of both perennial ryegrass and cocksfoot.

Rough-stalked meadow grass (Poa trivialis) however was a problem both in large and small seeded crop species. In timothy it approximates in shape, size and weight but in ryegrasses and cocksfoots the reason for its presence in the cleaned seed is due to each seed having attached to its base a number of basal hairs, which cling to the crop seeds or cause clustering of the weed. It is the presence of these basal hairs which prevent the easy cleaning of Poa trivialis seed from the larger seeded crop species.

Bent grasses (Agrostis spp.) were a problem in timothy mainly an account of its structural similarity, but unlike Poa trivialis it has never been regarded as a problem in larger seeded crop species.

(4) Examination of the flame treated seed showed that the basal hairs of Poa trivialis were effectively burnt off and the reduction in the number of seeds from 388 in the untreated to 12 in the treated (see Table 3) is a measure of the effectiveness of this treatment, in making this weed easier to clean out. The current standard for certification of cleaned grass seed allows up to 50 seeds of Poa trivialis in a 5 g. sample of meadow fescue and the 12 seeds found after treatment is within this limit.

Tables 3 and 4 also show that the crop seed germination was unharmed though there was a reduction of germination capability of Poa trivialis from 97% in the untreated to 89% in the treated sample. The appearance of the crop seed sample was not affected.

Some implications concerning commercial application of this treatment

If the method is going to be introduced commercially, its application would differ markedly from the model described. Firstly propane gas as used in the model would, in all probability, be uneconomic commercially; far too much heat was wasted for the work done and a more economic flame would need to be found. This might be a cooler but deeper flame as opposed to the very hot shallow fan flame produced by the model. Secondly the processor would have to decide on whether to treat the whole bulk of seed, before cleaning conventionally or whether to treat it after cleaning should it be found to contain more than the acceptable level of weeds. Alternatively the seed could be cleaned "hard" by conventional means to reach the desired purity standard, and only the cleanings exposed to the flame treatment. The cleanings from a crop could amount to 10% by weight and of this quantity 50% could well be good crop seed if the cleaning were done purposely hard. The last method would seem the more attractive from the point of view of economy.

References

GRIFFITHS, D.J., ROBERTS, H.M., LEWIS, J., STODDART, J.L., BEAN, E.W. (1967) Principals of herbage seed production. Tech.Bull.No.1 Welsh Pl.Breed.Stn. p.126

KLEIN, M.K., HENDERSON, S., STOESZ, A.D., (1961) Equipment for seed cleaning. Yb. Agric. U.S. Dip.Agric. p. 109.

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TRIALS FOR THE CONTROL OF SELF-SOWN SEEDLINGS AND OTHER WEED GRASSES IN GRASS SEED CROPS

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Summary. The control of self-sown seedlings and other grass weeds in grass seed crops was planned as an overall application at the end of summer. Simazine destroyed grass seedlings before tillering commenced and proved to be sufficiently persistent in action. The combination of dichlobenil + monolinuron acted on both volunteer plants and weed grasses in the course of tillering; it did not prevent a late weed emergence. Repeated applications of simazine or of dichlobenil + monolinuron proved to be more selective and more effective than single applications of these chemicals.

Grass weeds present in the inter-rows were eradicated in the spring by band application of paraquat.

INTRODUCTION

Grass weeds, whether they are volunteer plants derived from the crop itself or unsown species, are a worrying problem for the producers of grass seeds. These plants compete with the development of the crop and have seeds which are difficult if not impossible to separate by sorting. The Official Certification Agency therefore refuses the certification of crops invaded by such grass weeds.

Work carried out since 1961 has shown that dichlobenil can be used on crops older than one year. It becomes toxic for the mother plants when the treatment is done after mid-October (BOUCHET and de GOURNAY, 1965). This chemical, which is very active against self-sown seedlings, is ineffective against late emergence of grasses such as Alopecurus myosuroides and Bromus sp. (de GOURNAY, 1965). Monolinuron, which was tested by ARTHUR and SHILDRICK (1966), is fairly well tolerated by crops in Great Britain but has proved to be more phytotoxic in France. Simazine applied at the end of autumn or during the winter on established crops often proved to be phytotoxic in humid soil or cold periods. In addition, the effect of this triazine proved to be insufficient on Lolium sp. and above all on Bromus sp. as well as on Alopecurus myosuroides beyond the 3-leaf stage (de GOURNAY, 1965). Finally, the paraquat used in overall application has shown no selectivity (BOUCHET and de GOURNAY, 1965).

Behaviour tests carried out in 1967-68 were aimed at checking the advantage of early overall treatments at two periods against the first emerging grass weeds. The products tested were simazine and the combination dichlobenil + monolinuron. A directed spraying has been studied in order to eliminate grass weeds which subsist between the rows after the end of October, i.e. at a time when it is unreasonable to consider an overall application. Simazine, paraquat and the mixture simazine + paraquat have been compared.

METHODS AND MATERIALS

The overall applications were performed at two periods, during September and 6 weeks later in October. Inter-row application was made in March or April at the start of growth.

1) Herbicides and dosages used

a) overall application — rate (kg/ha a.i.)

		rate (kg/ha a.i.)
1st application	simazine	0,5 - 0,75 - 1
	dichlobenil + monolinuron (31,2% + 11,2%)	1,7 - 2,55 - 3,4
2nd application	id. 1st application	

		1st application	+	2nd application
1st application then 2nd application	simazine	0,5	+	0,5
	simazine	0,75	+	0,75
	dichlobenil + monolinuron(31,2%+11,2%)	1,7	+	1,7
	dichlobenil + monolinuron(31,2%+11,2%)	2,55	+	2,55

b) band application

simazine	0,5 - 1 - 1,5
paraquat	0,4 - 0,6 - 1,2
paraquat + simazine	0,2+0,25 - 0,4+0,5 - 0,6+0,75

2) Test conditions

Table 1 shows the situation and crop conditions for each trial. Overall spraying was performed with a portable constant pressure sprayer on plots of $2x10 = 20m^2$ Inter-row spraying was done by means of an apparatus fitted with a protective screen which prevented drifting of the herbicide on to crop plants. Amount of liquid per ha was 500 l.

Table 1
Experimental details

trial	sites	soil type	crop species	variety	sown	1st applicat.	2nd applicat.
1	M.&.L.	sandy-loam	Tall fescue	Manade	spring 66	11 Sep 67	30 Oct 67
2	M.&.L.	lime-clay	Meadow fescue	S 53	spring 66	15 Sep 67	18 Oct 67
3	Oise	lime-clay	Meadow fescue	Séquana	spring 66	9 Sep 67	23 Oct 67
4	Oise	lime-clay	Meadow fescue	Séquana	spring 66	20 Sep 67	27 Oct 67
5	Marne	clay	Cocks-foot	Floréal	May 67	15 Sep 67	23 Oct 67
6	Marne	clay	Hybrid ryegrass	Io	April 67	15 Sep 67	23 Oct 67
7	Sarthe	sandy-loam	Timothy	Pécora	Sep 66	3 Oct 67	11 Dec 67
8	Sarthe	sandy-loam	Perenn. ryegrass	Bocage	Sep 66	3 Oct 67	11 Dec 67
9	M.&.L.	silty-clay	Cocks-foot	Chantemille	spring 65	16 Mar 68	—
10	Marne	clay	Meadow fescue	Séquana	May 67	9 Apr 68	—

Experiments 1 to 8 related to the study of simazine and of the combination dichlobenil + monolinuron in overall application. Trials 9 and 10 are concerned with the study of paraquat, simazine and the mixture simazine + paraquat in strip application between the rows.

At the first time of application the self sown seedlings had 2 leaves and the crop was 10 to 25 cm high except in trial 3 where it had been mown a few days before. The test crops 9 and 10 were treated during the first spring growth. When the second application occurred, the self sown seedlings had 3 or 4 leaves and the crops were 30 to 35 cm high except in the case of test crop 1 which had been mown before the treatment and of test crop 7 and 8 which had been grazed.

RESULTS

Two tables summarize the visual observations : table 2 refers to the overall applications and table 3 to strip-spraying.

The figures shown are averages of records made in April or May, at a time when new emerging weeds can no longer compete with the crop. These figures are established on the basis of a number of observations which is limited and varies according to the crops and weeds. The results must therefore be interpreted with care.

Table 2

Herbicidal efficacy on the weeds and susceptibility of grass seed crops towards herbicides (overall application)

(scale from 0 = no effect, to 10 = total destruction)

	early spraying						late spraying						early+late spraying			
	simazine			dichlob. + monolin			simazine			dichlob. +monolin.			sima-zine		dich. +mon.	
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	1	2
Tall fescue	0	0	1	0	0	0	1	1	1	1	1	1	0	1	0	1
Meadow fescue	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1
Cocksfoot	0	0	3	0	0	1	3	3	3	2	3	3	1	1	0	1
Hybrid ryegrass	0	0	1	0	1	1	0	1	1	2	5	7	0	2	2	5
Perennial ryegrass	0	0	2	0	0	1	1	1	2	1	3	3	0	1	0	2
Timothy	0	0	2	0	0	1	1	1	2	1	3	3	0	1	0	2
Self sown seedlings	5	7	8	5	7	8	6	7	7	5	6	8	8	8	8	9
Agropyrum repens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alopecurus myosuroïdes	8	9	10	7	9	9	5	7	8	5	8	9	9	10	9	10
Agrostis vulgaris	5	8	8	6	9	9	3	6	9	5	8	9	8	9	9	9
Bromus sp.	-	-	-	-	-	-	9	9	9	9	9	9	9	9	9	9
Lolium sp.	6	7	9	6	7	9	7	8	8	8	8	9	9	9	9	9
Poa trivialis	7	7	8	6	7	7	6	7	8	6	6	7	9	9	9	9

Table 3

Herbicidal efficacy on the weeds and susceptibility of grass seed crops towards herbicides (inter-row application)
(scale from 0 = no effect, to 10 = total destruction)

	paraquat			simazine			paraq. +simaz.		
	1	2	3	1	2	3	1	2	3
Cocksfoot	0	0	0	0	0	0	0	0	0
Meadow fescue	0	0	1	0	0	1	1	1	1
Agropyrum repens	4	5	7	0	2	2	3	5	5
Alopecurus myosuroïdes	9	9	9	2	6	7	6	8	9
Poa trivialis	7	9	9	2	3	6	7	8	9

DISCUSSION

1) Overall spraying (Trials 1 to 8)

Simazine applied in September in quantities of 0.5 to 0.75 kg per ha was well tolerated by the crops. These doses were very effective on grass weeds having grown less than three leaves, but were less active on bigger plants. A dose of 1 kg per ha proved to possess good weed killing action but selectivity was often poor.

The combination of dichlobenil + monolinuron applied in September in quantities of 1.7 to 2.55 kg per ha was equally well tolerated. The action of this product was very quick but it sometimes did not allow the control of late emerging grass weeds. The amount of 3.4 kg per ha proved to be more or less toxic depending on the species of the crop.

Simazine and the dichlobenil + monolinuron mixture eventually injured crops treated in October. However, meadow fescue proved to be particularly resistant (tests 2, 3 and 4). Weed killing action was comparable to that obtained in September with the same products.

Split applications of simazine at 0.5 kg per ha in September and 0.5 kg per ha six weeks later were very well tolerated in 7 tests out of 8. The growth of cocksfoot (test 5) was temporarily checked ; that can be explained by unfavourable prevailing conditions such as working soil during wet periods. The effect on self-sown seedlings and grass weeds showed up slowly ; it persisted until the start of growth in March or April. Repeated applications of 0.75 kg per ha followed by the same dose (six weeks later) were less well tolerated by the crops in general.

Repeated applications of the dichlobenil + monolinuron combination in doses of 1.7 kg per ha in September followed by 1.7 kg per ha six weeks later proved to be selective in 7 tests out of 8. The hybrid rye-grass (test 6) was very much affected by this treatment. The effect on self-sown seedlings and other grass weeds was much quicker and less persistent than that of simazine ; some reinfestation was observed in the spring in most of the test crops.

2) Inter-row treatment (tests 9 and 10)

Paraquat did not adversely affect crops less than one year old ofter inter-row applications in the spring, provided spray droplets were prevented from coming into contact with the crop. It was effective at the lowest dosage, both on grass and dicotyledons weeds such as *Ranunculus sp.* and *Stellaria media*. However, effective action on *Poa trivialis* was only obtained in the range from 0.6 kg per ha upward. This product slowed down the growth of *Agropyrum repens*.

Simazine applied under the same conditions proved to be insufficiently active with regard to weed grasses even at doses of 1.5 kg per ha. The addition of simazine to paraquat did not improve herbicidal activity of the latter on grass weeds. In fact the applications were carried out too late on weeds that had grown too large, at a time when further emergence no longer was to be expected. Crop growth was slightly slowed down in the weeks following the treatment. This was probably caused by unduly late application of simazine, the check disappeared in the course of the summer.

CONCLUSION

The differences in susceptibility observed among the grass species with regard to the herbicides tested are difficult to analyse because the trials were scattered over a wide territory. In order to obtain valid information on this subject it would be necessary to group various crop species in one experiment so as to obtain identical soil and climatic conditions. It may be noted, however, that rye-grasses (see table 2) proved particularly susceptible to weed killers while fescue displayed a far greater resistance.

The application of simazine or of the dichlobenil + monolinuron combination was well tolerated by all the grass seed crops during the September and beginning-of-October treatments, in 1967. However, further experimentation is necessary to confirm selectivity, especially since simazine and above all dichlobenil applied at later periods may cause damage to the crop as was shown during the preceding years.

The use of these products at two dates six weeks apart at doses of 0.5 + 0.5kg per ha in the case of simazine and of 1.7 + 1.7kg per ha for the dichlobenil + monolinuron combination made it possible to attain a greater selectivity and better weed killing action. Under these conditions, it will be interesting to study the effect of a split application carried out, first with the dichlobenil + monolinuron compound, then with simazine. The dichlobenil + monolinuron combination - which was far more active in dry periods - should make it possible to quickly eliminate the first emerging weeds. Simazine which is more persistent, would ensure the destruction of later flushes.

Paraquat applied between the rows in quantities of 0.6 kg per ha by means of special equipment destroyed the grass weeds and various annual dicotyledons.

The addition of simazine to paraquat does not improve the latter's weed killing capacity during spring treatment. It is possible that the simazine + paraquat mixture offers a greater advantage when applied at the end of October when grass weeds are less developed and further germinations are still to be expected.

A series of tests is planned for 1968/1969 in order to verify these assumptions.

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REFERENCES

ARTHUR, T.J. and SHILDRICK, J.P. (1964) Control of Alopecurus myosuroïdes (black-grass) and other grass weeds in grass seed crops. Proc. 7th Brit. Weed Control Conf. 352-360.

ARTHUR, T.J. and SHILDRICK, J.P. (1966) Further experiments on the control of Alopecurus myosuroïdes (blackgrass) and other grass weeds in grass seed crops. Proc. 8th Brit. Weed Control Conf. 325-336.

BOUCHET, F. and de GOURNAY, X.P. (1965) Essais de destruction des ressemis et autres graminées adventices dans les cultures de graminées fourragères porte-graines. Proc. 3rd COLUMA Conf. 667-681.

de GOURNAY, X.P. (1964) Lutte contre les ressemis et les graminées adventices dans les cultures porte-graines de graminées fourragères. Fourrages 18, 19-39.

de GOURNAY, X.P. (1965) La lutte contre les ressemis dans les cultures porte-graines de graminées fourragères. Weed Res. 5, 285-304.