CONTROL OF BLACKGRASS *(ALOPECURUS MYOSUROIDES)* IN GRASS SEED CROPS WITH PROPHAM AND CIPC

by

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As trials in the United States indicated that annual grass weeds could be controlled in seed crops of perennial grasses by the use of propham and CIPC, work was undertaken to see if these chemicals could be used for the selective control of blackgrass (*Alopecurus myosuroides*), which is a very troublesome weed in grass seed crops.

Greenhouse tests showed that 3 lb./acre of propham or CIPC would control blackgrass providing it was applied before the 3-leaf stage. In field tests it was found that 4 lb./acre of propham or CIPC applied in October was satisfactory for the control of blackgrass in crops of meadow fescue, cocksfoot and timothy in their second and subsequent harvest years. Crops in their first harvest year were liable to damage from this treatment and the technique was, therefore, dangerous under these circumstances. As blackgrass is mainly a problem in the first harvest year, the technique is of very limited use in combating this problem.

Introduction

Blackgrass (*Alopecurus myosuroides*) is a very troublesome weed in perennial grass seed crops, especially in the eastern counties. It not only competes with the crop in the field, but the presence of more than one plant per square yard in the crop renders it ineligible for certification under the Aberystwyth Seed Crop Certification Scheme.

Perennial grasses for seed are normally sown in the spring and the first crop is taken the following summer. Blackgrass is most troublesome in the first harvest year, for in subsequent harvest years the crop is more competitive. Freed *et al.*[1] found that it was possible to control annual grasses in crops of perennial grasses for seed by the application of propham or CIPC in the autumn providing the crop was well established. Work was, therefore, started at the National Institution of Agricultural Botany, Cambridge, and continued at Plant Protection Ltd., both in the greenhouse and in the field, to determine the rate of these chemicals that would control blackgrass and the best time to apply them. At first, field work was confined to crops in their second harvest year in order to avoid damage as much as possible, but subsequently phytotoxicity trials have been carried out on crops in their first harvest year.

Experimental

(1) *Greenhouse experiments*

The preliminary unreplicated trial was started in December 1954 and was designed to study the effect of rates of application, stage of growth and temperature on the control of blackgrass by CIPC. Tests were made using 1·5 and 6 lb./acre, applied pre-emergence and at the 1–2- and 3–4-leaf stages. Tests were made in the open and in heated and unheated greenhouses.

Sixty seeds were planted in seed boxes which were kept in the heated greenhouses until spraying. The seeds were sown on 8th December, 1954.

The results obtained are shown in Table I.

Table I

First trial on blackgrass control by CIPC

Growth stage at spraying	Date	Number of plants per box: Outside			Unheated greenhouse			Heated greenhouse		
		1·5 lb.	6·0 lb.	Control	1·5 lb.	6·0 lb.	Control	1·5 lb.	6·0 lb.	Control
Pre-emergence	8.12.54 sprayed	0	0	0	0	0	0	0	0	0
	28.2.55	0	0	0	0	0	33	0	0	36
1–2 leaf	29.12.54 sprayed	33	31	26	30	32	36	37	30	32
	28.2.55	3	0	26	0	0	36	0	0	32
3–4 leaf	18.2.55 sprayed	35	40	26	35	33	36	25	31	32
	25.3.55	35	40	26	33	31	36	23	31	32

(dose rates are lb./acre)

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The second greenhouse trial in essence duplicated the first one, but spraying was done at more advanced stages of development of the plants.

Sixty seeds were planted per box and there were five replicates. All seeds were sown in the greenhouse, the first batch on 19th April, 1955, the second batch on 9th May, 1955, and the final sowing was on 3rd June, 1955. All the boxes were sprayed on 7th June, 1955, and the final assessments were made on 18th July, 1955. The results obtained are given in Table II.

Table II

Second trial of blackgrass control by CIPC

Growth stage at spraying	Date	Number of plants					
		Outside			Heated greenhouse		
		1·5 lb.	3·0 lb.	Control	1·5 lb.	3·0 lb.	Control
Pre-emergence	7.6.55 sprayed	0	0	0	0	0	0
	18.7.55	1	0	64	0	1	119
2–4 leaves	7.6.55 sprayed	158	171	151	159	140	131
	18.7.55	9	6	153	36	20	142
4–6 leaves	7.6.55 sprayed	159	159	159	162	159	148
	18.7.55	130	138	162	164	158	145

Both these trials showed that the stage of growth of blackgrass at the time of spraying was very important and that the earlier the chemical was applied the more effective it was. Once the plants had reached the 3–6-leaf stage they were practically resistant to CIPC.

(2) *Field trials*

(*a*) In the autumn of 1954 two field trials were laid down, both on crops in their second harvest year on plots 12 yd. × 2 yd. The first was on a crop of S.48 timothy sown in 18-in. drills and the second on a broadcast crop of S.23 perennial ryegrass. CIPC was applied at 1·5, 3 and 6 lb. in 100 gal. of water/acre with a knapsack sprayer.

There were two times of application:

S.48 timothy: (1) 12th Oct., 1954; (2) 15th Nov., 1954

S.23 perennial ryegrass: (1) 13th Oct., 1954; (2) 16th Nov., 1954

Prior to harvest a count was made of the number of blackgrass plants in each plot and the results for the timothy trial are shown in Table III. Severe crop damage was noted in those plots treated with 3 and 6 lb./acre in November.

The outstanding result from the perennial ryegrass trial was the complete absence of blackgrass from all plots including controls. Crop damage was more extensive than in the timothy trial, being noticeable at rates of 3 lb./acre and above at both times of application.

(*b*) In the autumn of 1955 the work on timothy and perennial ryegrass was continued, one trial being carried out on each of these crops using CIPC and propham at 2 and 4 lb./acre applied as a spray, and propham at 2 and 4 lb./acre applied as pellets.

The plot size was 12 yd. × 2 yd. with a 1-yd. path between plots. The plots were randomised within the blocks with one control plot in each block, and there were three replicates.

There were two times of application:

S.48 timothy: (1) 29th Sept., 1955; (2) 25th Oct., 1955

S.23 perennial ryegrass: (1) 26th Sept., 1955; (2) 27th Oct., 1955

Small trials designed to determine the susceptibility of meadow fescue (S.53) and cocksfoot (S.143) to CIPC were also laid down, 4 lb./acre being applied at two dates, 29th September, 1955, and 25th October, 1955.

All the trials were sprayed with an Oxford Precision Sprayer at 20 gal./acre. The perennial ryegrass crop was broadcast and the others were sown in 18-in. drills. All crops were in their second harvest year.

A count of the number of blackgrass plants in each plot was made in the timothy trial prior to harvest (Table IV). There was no sign of any crop damage on any of these plots, nor on the crops of cocksfoot and meadow fescue.

In the perennial ryegrass trial, CIPC at 4 lb./acre caused severe damage at the first application, and CIPC at 2 lb./acre and propham at 2 and 4 lb./acre caused slight damage at the second application. There were no blackgrass plants in any of the plots including controls.

Table III

Average number of blackgrass plants per plot

(field trials, 1954)

CIPC rate, lb./acre	Date of spraying 12.10.54	15.11.54
1·5	37	5*
3·0	9*	8*
6·0	2*	0*
Control	103	126

Table IV

Average number of blackgrass plants per plot

(1955 trials)

Chemical and dosage, lb./acre		Date of spraying 21.9.55	25.10.55
CIPC	2	65·0	7·3*
,,	4	18·3*	14·6*
Propham	2	72·0	21·6*
,,	4	86·6	9·6*
,, (pellets)	2	113·0	75·3
,, ,,	4	52·0	43·0
Control		69·0	101·0

* Plots in which the number of plants had been reduced below the certification standard of 1 plant per sq. yd.

(*c*) In 1956, four trials were laid down with a view to obtaining more data on the effect of propham and CIPC on grass seed crops in their second harvest year. Two trials were laid down on cocksfoot (S.143 and S.26), one on meadow fescue (S.53) and one on timothy (S.48).

The chemicals were applied at 2 and 4 lb. active ingredient/acre with an Oxford Precision Sprayer in 19 gal. of water/acre. There were two dates of application. Each trial consisted of four blocks of ten randomised plots, each plot being 12 yd. × 2 yd.

In only one trial, the S.143 cocksfoot, was there enough blackgrass for a count to be made (Table V), and both propham and CIPC brought the weed infestation within the limits of the Seed Crop Certification Scheme.

Table V

Average number of blackgrass plants per plot

(1956 trials)

Date of application	30.9.56		10.10.56		30.10.56				
Chemical	Propham		CIPC		Propham		CIPC		Control
Rate, lb. active ingredient/acre	2	4	2	4	2	4	2	4	
Number of blackgrass plants in 24 sq. yd.	18·5	12	4·25	9·75	9·25	10·75	6·5	6·25	26·25

In two trials, the S.26 cocksfoot and the S.53 meadow fescue, there was a considerable amount of aftermath at the time of spraying and here propham at 4 lb./acre caused damage to the crop. In the other two trials where there was little aftermath, no damage was recorded.

Crop vigour gradings are shown in Table VI.

Table VI

Crop vigour grading

(1956 trials)

S.53 Meadow fescue									
Date of application	26.9.56		11.10.56		31.10.56				
Chemical	Propham		CIPC		Propham		CIPC		Control
Rate, lb. active ingredient/acre	2	4	2	4	2	4	2	4	
Average vigour grading	8·3	3·3	8·6	9·0	7·3	4·4	8·8	9·0	8·6
S.26 Cocksfoot									
Date of application	26.9.56		12.10.56		31.10.56				
Chemical	Propham		CIPC		Propham		CIPC		Control
Rate, lb. active ingredient/acre	2	4	2	4	2	4	2	4	
Average vigour grading	9·0	8·1	8·4	8·8	8·0	4·9	8·9	8·5	9·0

(Grading 10–full crop; 0—complete kill)

(*d*) In view of the fact that blackgrass is most trouble in seed crops in their first harvest year, four trials were laid down in 1957 to determine the susceptibility of perennial ryegrass (S.101), cocksfoot (S.143), timothy (S.48) and meadow fescue (S.215) to propham and CIPC in the first harvest year.

The chemicals were applied at 2, 4 and 6 lb. active ingredient/acre with an Oxford Precision Sprayer in 20 gal. water/acre. There were two times of application, early and late October.

By the following spring all the crops were showing damage, especially from the later application. Just prior to harvest most of the crops had recovered from this initial setback at the 4-lb. rate but in most cases the 6-lb./acre rate was still giving signs of crop toxicity at this stage from the second spraying. The crop vigour gradings are shown in Table VII.

Table VII

Crop vigour grading
(1957 trials)
Dosages in lb./acre

Crop	Date of assessment	Treatments: 1st application, 4th–6th Oct. Propham 2	Propham 4	Propham 6	CIPC 2	CIPC 4	CIPC 6	2nd application, 25th–26th Oct. Propham 2	Propham 4	Propham 6	CIPC 2	CIPC 4	CIPC 6	Control
S.101, perennial ryegrass	5.3.58	9·25	8·75	8·0	9·25	8·75	8·0	9·0	8·25	3·75	8·5	4·25	1·25	9·25
	18.6.58	10·0	9·5	7·75	10·0	9·0	9·25	10·0	9·25	8·5	9·0	9·5	4·75	9·5
S.143, cocksfoot	5.3.58	8·5	8·25	8·75	8·5	8·0	8·0	8·25	7·5	4·5	8·5	7·75	5·75	8·25
	18.6.58	9·75	9·5	10·0	9·75	8·0	10·0	9·0	9·25	7·5	8·75	9·5	8·5	9·25
S.48, timothy	6.3.58	10·0	9·25	8·0	10·0	9·75	8·75	9·0	6·75	4·25	8·5	4·75	5·25	10·0
	19.6.58	9·75	9·0	7·75	10·0	9·75	9·25	9·5	4·75	3·25	9·25	3·0	0·5	9·5
S.215, meadow fescue	5.3.58	8·25	6·75	5·75	8·25	6·75	6·25	8·0	5·75	4·0	6·5	3·25	2·25	8·25
	18.6.58	8·75	7·0	10·0	9·5	9·5	8·25	10·0	9·75	7·25	8·5	7·25	5·0	9·0

(Grading: 10—full crop; 0—complete kill)

Discussion

Greenhouse and field tests have shown that both propham and CIPC will control blackgrass at 3–4 lb./acre providing the chemical is applied before the 3–leaf stage. At rates of 4 lb./acre both these chemicals applied in October are relatively safe on seed crops of meadow fescue, cocksfoot and timothy in their second and subsequent harvest years, but from the limited work carried out it appears that there is danger of damage to the crop in its first harvest year.

The main trouble from infestations of blackgrass is in the first harvest year of grass seed crops, and hence the possibility of damage to the crop makes the technique of applying either propham or CIPC in October prior to harvest much too dangerous. The technique is, therefore, of very limited use for the control of blackgrass in grass seed crops.

Reference

[1] Freed, V. H., Bayer, D. E., & Furtick, W. R., *Inform. Circ. Agric. Exp. Sta., Oregon State Coll.*, 1953, No. 514

EFFECT OF PROPHAM AND CIPC ON GRASS SEED CROPS SPRAYED IN THE YEAR OF SOWING

by

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The experiment was conducted to examine the effect of propham and CIPC on inflorescence production in four grass species, after spraying in the year of sowing at rates of 3 and 6 lb./acre on four dates in the autumn.

There was no effect with any treatment applied in September, but damage, greatest at the higher rates, occurred with October and November sprayings. Where heavy rain followed spraying, damage was greatly increased on all strains. When serious damage occurred, CIPC proved more toxic than propham on all species except cocksfoot.

Ryegrass and meadow fescue were most susceptible to damage and timothy slightly more susceptible than cocksfoot.

Introduction

The value of propham and CIPC for the control of blackgrass (*Alopecurus myosuroides*) in well-established grass seed crops was described at the last conference.[1] In view of the need for control of blackgrass in the year of sowing, an experiment was undertaken at this Institute to study the effect of these chemicals on maiden crops of four grass species.

Experimental

The experiment was sited on a field which had been in annual crops for many years. The soil was a sandy loam overlying chalk at varying depth. Grass strains were sown in 2-ft. rows on 23rd April, 1956. Spraying was carried out at four dates in the autumn. The plot size was 6 ft. × 4 ft. for each of the six strains. Each randomised block, of which there were four, contained four control plots.

Species

The species studied were perennial ryegrass S.23 and S.24, cocksfoot S.143 and Danish, timothy S.48 and meadow fescue S.215.

Propham was used as a wettable powder at 3 and 6 lb./acre and CIPC as emulsifiable oil at 3 and 6 lb./acre. All treatments were applied by Oxford Precision Sprayer at 20 gal./acre.

The dates of spraying were 13th September, 2nd October, 22nd October and 21st November, 1956.

In this trial it was not considered practicable to measure weight of seed and an assessment was obtained by a count of seed heads in a given length of drill. Counts were taken as each grass became fully emerged, from two random 1-ft. lengths per plot. Results are given in Table I.

Results

Table I

Mean number of flowering heads per foot of drill

Strain	Control mean and S.E.	Chemical	Date and rate of application in lb. a.e./acre: 13.9.56, 3	13.9.56, 6	2.10.56, 3	2.10.56, 6	22.10.56, 3	22.10.56, 6	21.11.56, 3	21.11.56, 6	S.E. of means
Perennial ryegrass, S.23	229 ± 10·1	Propham	223	249	179	80	213	187	182	143	± 20·2
		CIPC	243	235	95	18	190	195	163	163	
Perennial ryegrass, S.24	215 ± 8·3	Propham	220	228	216	115	201	179	195	134	± 16·5
		CIPC	217	218	92	6	190	194	213	106	
Cocksfoot, Danish	66 ± 2·7	Propham	65	69	53	22	60	62	73	58	± 5·4
		CIPC	73	58	47	23	58	56	66	51	
Cocksfoot, S.143	66 ± 2·8	Propham	58	61	56	34	70	51	69	41	± 5·5
		CIPC	69	75	47	21	64	71	61	49	
Timothy, S.48	86 ± 4·5	Propham	96	90	59	23	76	90	83	89	± 8·9
		CIPC	84	82	56	12	73	65	76	75	
Meadow fescue, S.215	124 ± 3·8	Propham	117	129	94	9	131	89	106	74	± 7·5
		CIPC	126	137	14	1	114	74	89	61	

The effect of spraying could first be detected in 3–4 weeks, in the form of browning of the leaf tips. By December it was evident that all plots treated on 2nd October were damaged to a greater extent than plots treated at other dates. This damage at the second spraying date was associated with heavy rainfall before and after spraying (Table II).

Table II

Rainfall (in.) in relation to spraying date

Days before and after spraying	Date of spraying 13.9.56	2.10.56	22.10.56	21.10.56
−2	0·09	0·25	—	—
−1	—	0·47	—	—
Spraying	—	0·46*	—	—
+1	—	—	0·05	—
+2	—	0·05	0·04	—
+3	—	—	—	—
+4	—	—	—	—
+5	—	—	0·05	0·03

* rain fell after spraying

By March 1957 there was no green vegetation on plants of ryegrass and meadow fescue treated on 2nd October with propham at 6 lb./acre or with CIPC at 3 lb./acre. On plants treated with 3 lb./acre of propham most of the leaves were partly green. Cocksfoot and timothy were damaged, but to a lesser degree. Damage at the other three dates remained relatively small, with a tendency to greater browning of foliage with the higher rates at the later dates.

With spring growth, a few green leaves were produced on the badly damaged plots but final assessment showed little recovery.

All species suffered damage under certain conditions but in general meadow fescue and perennial ryegrass were more susceptible than timothy or cocksfoot. There was little difference in reaction between S.23 and S.24 ryegrass, or between S.143 and Danish cocksfoot. Difference between chemicals was only observed where severe damage occurred, CIPC being more toxic than propham on all species except cocksfoot.

Discussion

The most notable result in this experiment was the severe damage sustained by the sown grasses after spraying on 2nd October. Since the chemicals enter the plant principally through the root it is suggested that the heavy rain which followed spraying on that date may have carried the chemicals down into contact with the roots of the crop before any appreciable breakdown had taken place. While the results as a whole indicate that grasses sown in spring without a nurse crop can tolerate spraying with propham and CIPC in September or October, at rates which should give control of blackgrass, this particular result indicates a serious weather hazard. This hazard, moreover, may not be confined to maiden crops.

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Reference

[1] Jeater, R. S. L., *Proc. Brit. Weed Control Conf., 1956*, p. 247

EFFECT OF CIPC AND PROPHAM ON YOUNG GRASS SEED CROPS

by

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Introduction

In this country certain annual grasses can be a serious problem as weeds in grass seed crops. They are unaffected by the more commonly used herbicides and their seeds are difficult to separate from those of crop grasses by seed-cleaning machinery, while the rate of multiplication of these annual grasses may be very rapid.

The work of Freed *et al.* in the U.S.A. with CIPC and propham on a similar problem suggested the possibility of controlling annual grass weeds in established grass seed crops.[1] Consequently, in conjunction with the A.R.C. Unit of Experimental Agronomy at Oxford, a series of trials have been carried out at the N.I.A.B. over the last four years. The object of these has been the control of blackgrass (*Alopecurus myosuroides*), the annual grass weed which most frequently causes trouble, and to ascertain the likelihood of damage to the economic crop. Both CIPC and propham are most effective against germinating seed and young seedlings and the appropriate time to spray for control of black grass is therefore in the autumn when the majority of shed seeds has just germinated.

The early trials carried out from 1954 to 1956, reported by Jeater in 1956,[2] were made on established grass seed crops at least 18 months old. Infestation with blackgrass is, however, generally more serious in the first harvest year of the seed crop. To control blackgrass at this early stage in the life of the crop it is necessary to spray during the autumn of the year of establishment when the crop grasses are approximately 6 months old. The later trials from 1956 to 1958 were therefore carried out to determine whether grass seed crops can be sprayed safely at this stage in their development with rates of chemicals likely to give an effective control of blackgrass.

Experimental

The trials made were—

1956–57.—Single basic trial on the N.I.A.B. trial ground at Cambridge.

1957–58.—Two basic trials at Hill Farm, Lolworth, Cambridge, and six smaller trials on field crops in Norfolk, Suffolk and Essex.

In the basic trials both CIPC and propham (=IPC) were applied at 3 lb. and 6 lb./acre. Only the lower rate was applied in the tension trials. The earliest trials had shown that the same treatment made at different times in the autumn resulted in varying degrees of damage. To examine this effect all the trials were sprayed at three dates in the autumn. The aim was to spray at fortnightly intervals but weather conditions, particularly the ground wind speed, determined the actual dates of spraying, which ranged from the end of September to mid-November.

Both CIPC and propham act through the plant roots. The amount of active chemical which passes into the soil and is available to the plant will be determined by a number of factors—ground cover (by weeds, stubble or the crop), the rate of volatilisation of the chemical, the condition of the soil and the subsequent rainfall. To take some account of these factors the following records were made:

Rainfall data were obtained for the period of the trials from the nearest meteorological station. At the time of application the temperature was recorded and the rate of evaporation assessed from the wind speed and general humidity.

The varieties of crop grasses used for trials were chosen as representative of the main types grown for seed in this country.

Perennial ryegrass, S.24:	Early flowering.
,, ,, S.23:	Late flowering.
Cocksfoot, S.37:	Intermediate in flowering.
,, S.143:	Late flowering.
Timothy, S.48:	Late flowering.
Meadow fescue, S.215:	Intermediate in flowering.

The results were assessed by eye at intervals up to ear emergence and, in the first basic trial, head counts were made, but this was considered unnecessary for subsequent trials. The first sign that the plants have been sprayed is a loss of leaf sheen which is probably a contact effect and in any case is only temporary. Where damage occurs the plants show a higher proportion of yellow leaves so that such plots can be picked out readily by their colour. Where moderate damage occurs, the plants do not recover from the yellowing phase in the autumn but continue to show signs of damage the following spring when they are retarded in comparison with unsprayed plants, with consequent reduction of seed yield. Greater damage than this where the plants die right back, has been recorded as serious.

Discussion of results

It will be seen from the details of individual trials in the Appendix that the results showed considerable variation. They do indicate, however, that:

(1) Both CIPC and propham applied at rates and times likely to control blackgrass can cause damage to young grass seed crops under certain conditions.

(2) The degree of damage depends on several factors:

- (*a*) Size of crop plants—large, well-developed plants are less liable to damage than small, poorly developed plants such as are found in undersown crops.
- (*b*) The chemical and rate of application—CIPC is more toxic than propham.
- (*c*) The amount of cover of the soil by the crop or by weeds—the damage was greater where this was low.
- (*d*) Rate of evaporation at time of application. Slow evaporation tends to increase damage. Propham is more volatile than CIPC.
- (*e*) Rainfall following spraying. Heavy rain tends to increase damage.

Severe damage did occur in some trials on perennial ryegrass, timothy and meadow fescue, even with only 3 lb./acre, particularly where heavy rain followed spraying.

Where the crop grasses are damaged or set back they offer less competition to weeds and these invade the plots after the chemicals cease to be active, with the result that damaged plots often become infested with more weeds, including blackgrass, than the controls. It is, therefore, hazardous to apply chemicals which could cause moderate or even severe damage to the crops under unfavourable conditions, especially when such an unpredictable factor as rainfall can be decisive.

Cocksfoot is, so far, the only crop grass species which has shown no more than slight damage following spraying with CIPC and propham in the year of establishment. As a result of these trials it has been decided not to continue work with CIPC and propham for blackgrass control at this stage in perennial ryegrass, timothy and meadow fescue, but further work with cocksfoot is in progress.

References

[1] Freed, V. H., Bayer, D. E., & Furtick, W. R., *Inform. Circ. Agric. Exp. Sta., Oregon State Coll.*, 1952, No. 514.

[2] Jeater, R. S. L., *Proc. Brit. Weed Control Conf.*, *1956*, I, p. 247

Appendix

The trials had certain features in common:

Soil type—heavy clay.
Crop grasses—S varieties, 6 months old except in one case as stated.
Replicates—2 or 3 of plots 6 ft. × 6 ft. or 6 ft. × 15 ft.
Rainfall data—obtained from the N.I.A.B., Cambridge, or the nearest recording station to the trial.

1956–57

Location: N.I.A.B. trial ground, Cambridge.

Dates	early October	late October	mid-November
Rainfall for preceding 4 days	½ in. day before	nil	⅓ in. day before
At application:			
(*a*) temperature	58°F	45°F	45°F
(*b*) rate of evaporation	slow	slow	slow
Rainfall for following 4 days	slight	slight	slight

	early October				late October				mid-November			
	CIPC		Propham		CIPC		Propham		CIPC		Propham	
	3	6	3	6	3	6	3	6	3	6	3	6
Perennial ryegrass												
S.24	—	—	—	M	—	M	—	—	M	M	—	M
S.23	—	M	—	M	—	S	—	M	—	S	—	S
Cocksfoot												
S.37	—	—	—	—	—	—	—	M	—	M	M	—
S.143	—	—	—	—	—	M	—	—	—	M	—	M
Timothy												
S.48	—	M	—	—	—	—	—	—	M	M	—	M
Meadow fescue												
S.215	M	S	—	S	M	S	—	M	M	S	—	S

M = moderate damage to seed crop—plants obviously affected and retarded with reduced seed yields.
S = severe damage to seed crop—plants nearly or completely killed with little or no seed yield.
— = no damage to seed crop, or slight damage with recovery.

1957–58

Trials 1 and 2

Location: Hill Farm, Lolworth, Cambridge.
Varieties: Trial 1: S.24 and S.23 perennial ryegrass, S.37 cocksfoot 6 months old. (Plots of S.143 cocksfoot, S.48 timothy and S.215 meadow fescue were sown, but failed.)
Trial 2: S.24 and S.23 perennial ryegrass, S.143 cocksfoot and S.48 timothy $4\frac{1}{2}$ months old.
Spraying dates: End September, mid-October, late October.
Conditions: Similar on all three dates but third application followed by slight rainfall.
Chemicals: CIPC and propham at 3 and 6 lb. in Trial 1 and 3 lb. only in Trial 2.
Results: No damage resulted from treatments with propham. CIPC at 6 lb. caused moderate damage to S.24 on the first date and severe damage to S.24 and S.23 on the last. CIPC at 3 lb. caused slight damage only in Trial 2 to S.24 and S.23 on the last date (i.e., timothy and cocksfoot undamaged).

Trial 3

Location: Dereham, Norfolk.
Variety: S.48 timothy in drills, undersown and poorly developed.
Spraying dates: Early October, mid-October, late October.
Conditions: Similar on all three dates, wet with rain either before or after spraying.
Results: Severe damage to seed crop at all dates with CIPC, moderate damage with propham at early and mid-October, severe damage with late October spraying (all 3 lb./acre).

Trial 4

Location: Hitcham, Suffolk.
Variety: S.143 cocksfoot in drills and undersown.
Spraying dates: Early October, mid-October, end October.
Conditions: Heavy rain followed 2 days after second application, but otherwise conditions were similar.
Results: No obvious damage from either CIPC or propham at 3 lb. Plots became irregular due to uneven application of nitrogen making accurate assessment impossible.

Trial 5

Location: Felsted, Essex.
Varieties: S.143 cocksfoot, direct sown in wide drills, S.24 perennial ryegrass, broadcast and undersown.
Spraying dates: Early October, mid-October, early November.
Conditions: Heavy rain followed second application and slight rain the last.
Results: Propham at 3 lb. caused no damage. CIPC at 3 lb. damaged S.24 severely on second date and moderately on third date (i.e., cocksfoot undamaged).

Trials 6 and 7

Locations: Foxearth and Halstead.

Dates	early October	mid-October	early November
Rainfall for preceding 4 days	trace	trace	moderate
At application:			
(*a*) temperature	58°F	58°F	48°F
(*b*) rate of evaporation	fairly fast	fast	average
Rainfall for following 4 days	trace	heavy	slight

Results:

Meadow fescue, S.215:	CIPC	—	S	S
	Propham	—	S	M

Discussion on the three preceding papers

Mr. R. Jeater.—I would like to ask Mr. Jones whether dalapon has been tried for the control of blackgrass in grass seed crops.

Mr. L. Jones.—No, not at Hurley, since dalapon is taken in through the leaf and difficulties may arise. At Hurley ryegrass has been killed by dalapon at 2 lb./acre. Doses of dalapon would therefore have to be low and even this may affect seed yield of the economic grasses.

Mr. F. R. Stovell (Shell Chemical Co.).—We have had a small amount of experience of the control of blackgrass in cocksfoot. In one case, $\frac{1}{2}$ lb. of a formulation of dalapon per acre depressed the blackgrass sufficiently for the crop to be certified, and a seed cut to be taken without contamination by blackgrass.

Mr. R. Jeater.—Would it be possible to apply propham or CIPC in the spring, and then sow grass seed in the following autumn and obtain a satisfactory seed crop in the next year?

Mr. G. W. G. Briggs.—I think I would prefer to think in terms of autumn treatment followed by spring sowing. We do find that most grass species require to be sown in the spring if satisfactory yields are to be obtained in the first harvest year. The behaviour of blackgrass throughout the year has also to be taken into account: it will flower from late May into early winter, the bulk of seeds being shed during the latter part of the summer. Under favourable conditions these produce vigorous plants which overwinter and can produce a dense infestation the following year.

I should also like to mention that a committee considering quality in seeds has recently recommended that blackgrass should be included in the list of noxious weeds scheduled under the regulations made under the Seeds Act, so you can see we have quite a problem in front of us.

CHEMICAL TREATMENT OF BRACKEN *(PTERIDIUM AQUILINUM)* IN SCOTLAND

Trials on the effects of various chemical herbicides on bracken have been continued in Scotland.

Emphasis is laid on the need for direct attack on the organs of growth and extension, that is to say, on the well-protected underground stem. The effectiveness of a herbicide may be measured by its effect on the young, meristematic tissues of the stem tips and frond-buds on the secondary branches. A method of assessing these effects has been devised by direct sampling of the underground stem and it is proposed that the value of any treatment may be judged by (*a*) the number and condition of fronds on unit areas in the years following treatment; and (*b*) by analysis of samples of secondary branches at periods after treatment.

Using this form of analysis, field trials have been carried out with ammonium sulphamate, borates, sodium chlorate, aminotriazole and dalapon, some of the chemicals being applied by foliar spraying and others by soil application.

As a result of these trials it is suggested:

(1) that contact herbicides such as ammonium sulphamate are vigorous defoliants but have no lasting effects whether applied to fronds or through the soil, and that density of a bracken stand appears unimpaired even in the year following treatment;

(2) that massive doses of sodium chlorate, various borate compounds and mixtures of borates and sodium chlorate are effective in killing bracken in the upper soil layers. This is by direct contact through the soil, and there is no evidence of translocation;

(3) that dalapon and aminotriazole are translocated to the rhizome when applied as foliar sprays and both can produce effects on frond tissues in the year after treatment. Dalapon has a retarding effect on frond-bud extension; but no systemic effects have been observed on the rhizome or rhizome apices with either chemical;

(4) that conditions which break the dormancy of dalapon-treated frond-buds are as yet unknown;

(5) that translocation of a chemical compound from the fronds to the underground stem and frond-buds of field bracken is now confirmed.

Part I. Method of Measuring the Effects of Treatment

by
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Introduction

Among the special problems presented by the common bracken fern (*Pteridium aquilinum*) is the difficulty of evaluating the effects of treatment. The usually accepted method of assessing frond number and height in the year after treatment, though convenient, gives little idea of the actual impact of the treatment on the organs of growth and extension. The fronds are, in any case, seasonal and transitory growths; and it is the massive, spreading, underground (and therefore well-protected) stems, from which the fronds arise, that should be the real centre of attack. To understand the value of any form of treatment, then, it is necessary to know what is happening to this underground stem. In an established stand of bracken the stem consists of a tangled mass of secondary branches, which does not easily suggest any method of statistical or other analysis; and so the purpose of the first part of this paper is to offer a mode of evaluation of treatment.

When a unit area of bracken land is dug up, a mass of rhizome consisting of various lengths of the underground stem can be taken out, and the stem is then seen as a storage organ carrying considerable amounts of carbohydrates which can be drawn on for further growth and frond production. The theory that these stores would be so depleted by frond removal that the storage organ would shrivel and die is not borne out by actual trial: the food stores are apparently so massive that they can withstand successive frond removal for long periods. The basic effect of mechanical frond removal is the initiation of large numbers of small frond-initials, any one of which may establish a new centre of growth. Thus, starvation by frond destruction, whether effected by mechanical or other means, may be a very prolonged and not very rewarding project.

Composition of rhizome mass

Further examination of the rhizome mass of field bracken shows that it is composed of a large number of secondary branches, each with a large apical region which is the area both of frond initiation and of extension. Among these branches, three types may be distinguished:

(*a*) current year fronds arise on branches, each of which has a secondary stem apex a few cm. beyond the frond base. In the late summer these stem tips carry frond buds—one or two at each tip—which will form the frond population for the following year (Fig. 1). These branches are mostly running through the upper levels of the soil;

(*b*) other stem branches, also found for the most part in the upper soil levels, are associated with fronds older than the current year: while some of these stem tips are secondary shoots which have gone through one year of dormancy, others may be older; but all are able to show the developing frond buds and stem tips just as in current year shoots. A proportion of the frond population in any year comes from such branches which have gone through a period of dormancy. Conditions that induce or break such dormancy are at present unknown; but undoubtedly these periods of dormancy add to the resistance to attack by the plant and its ability to restart growth by activated normal secondary branches (Fig. 2);

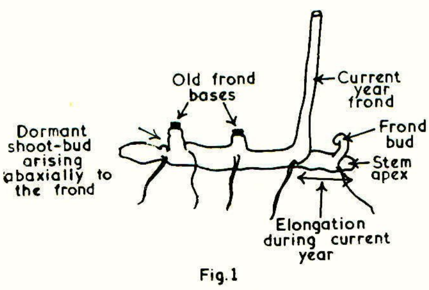

FIG. 1.—*Upper rhizome branches in September associated with current year fronds*

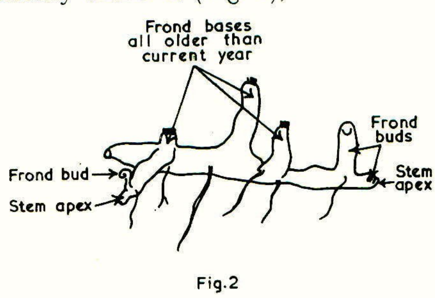

FIG. 2.—*Upper rhizome branches in September associated with fronds older than current year*

(*c*) thirdly, below the upper soil level branches (*a*) and (*b*) lie thicker, outward-spreading stems with long internodes and considerable starch reserves. These fork at infrequent intervals and fronds are infrequently initiated at their apices. These branches, with their massive food reserves, give the plant considerable resistance to most forms of attack. Under certain stimulation, they give off branches that act as types (*a*) or (*b*).

For purposes of evaluation, branches of the type (*a*) and (*b*) may serve as units; the state of the stem apex and the adjoining frond bud or buds can readily be assessed, and their behaviour before and after treatment readily analysed.

State of branch apices in untreated bracken

Examination of branch apices (*a*) and (*b*) above, in the West of Scotland suggests that the apex of a secondary stem becomes active about the end of June and the initiation of a frond bud becomes visible late in July. Growth of the stem appears to slow (but not necessarily to stop) during the early part of the autumn, while that of the frond bud or buds which it carries continues markedly for a time. These observations are in general agreement with the description for the behaviour of the bracken in Breckland, Cambridgeshire, described by Watt.[1] Table I

Table I

State in late September of upper level secondary branches of untreated bracken

Site	Branch apices associated with: Current year fronds — Rhizome tips/20		Current year fronds — Associated frond buds			Fronds older than 1 year — Rhizome tips/10		Fronds older than 1 year — Associated frond buds		
	Healthy	Dead or dying	Healthy	Dead or dying	Not visible	Healthy	Dead or dying	Healthy	Dead or dying	Not visible
Stirlingshire	20	—	19	—	1	9	1	10	1	2
Dunbartonshire										
Site (a)	20	—	21	—	—	10	—	10	—	—
(b)	20	—	12	—	8	10	—	9	—	1
(c)	20	—	18	—	2	10	—	6	—	4
Dumfriesshire	20	—	17	—	3	10	—	9	1	—
Perthshire	20	—	17	—	3	10	—	10	—	—
Isle of Mull	20	—	13	—	7	10	—	9	1	—
Dumfriesshire	20	—	17	—	3	10	—	6	—	4
Argyll	20	—	15	—	5	10	—	11	—	—
Average for 9 sites	20	—	16·5	—	3·5	9·9	0·1	8·8	0·3	1·2

gives an analysis for branches of the types (*a*) and (*b*) as seen for seven areas in the West of Scotland in late September–early October; and from this, the following points may be emphasised:

(1) in the early autumn, the branches of the bracken stem running near to the soil surface are in an active state with a large frond potential already formed for next year. In the areas examined, remarkably little dead material was present among the upper branches, and the great majority were in a healthy and even active state;

(2) the number of frond buds ready to expand in the succeeding year is very high by the end of September. A number of the stem apices were seen to carry more than one frond bud, this being true of about 25% of the stem apices at the bases of current year fronds and 33% of stems associated with fronds older than the current year. This suggests a higher rate of frond initiation than that reported by Watt[1] for the Breckland. An earlier estimation[2] of the ratio of frond buds to expanded fronds taken in September on a number of West of Scotland sites showed ratios varying from 1·46 to 2·27. Since the number of expanded fronds remains more or less the same on an area, the high frond-bud potential means either that a large number are lost through frost or mechanical damage before they can mature, or else that a considerable number remain in a dormant state below the surface of the soil. The latter might readily be stimulated to replace expanded fronds lost during the growing season. An excess of frond buds is probably one of the features in the development of the plant, and observations made on sites in Perthshire, Stirlingshire and Dunbartonshire gave mean figures for ratios of frond buds to expanded fronds as 1·93 in May (when the majority of the season's fronds were expanded above the ground) and 1·96 in September. Clearly, any chemical which had an inhibitory or damaging effect on frond-bud development would be an agent of active attack on the plant;

(3) the initiation of a visible frond-bud on the stem at the base of the current year's frond is not invariable: percentages varying between 5 and 35 of the apices without visible frond buds were found in late September; while in the case of shoots associated with fronds older than one year, the proportion varied between 5 and 20%. Such stems might, of course, initiate frond-buds at a later time, though at the time of analysis they were not visible;

(4) of the frond population for the next year, roughly two-thirds appear to be formed on stems immediately adjacent to fronds of the present year and one-third on stems older than one year. The period of dormancy which such stems can go through is so far quite undetermined.

The mean figures compiled from the data of Table I are useful as control figures against which data from treated plots may be assessed. It is therefore proposed to use the following data to record the full effect of any treatment:

(1) Frond development: (*a*) the number of fronds on a unit area of treated and untreated bracken. Such data should be compiled for at least three years; (*b*) the heights of 20 fronds from the same sites throughout the experimental period. Little value can be placed on the effects shown by fronds in the first year of treatment: frond development will be of greater significance in the succeeding years.

(2) Rhizome development: analysis of the branches types (*a*) and (*b*) above, with additional data, where necessary, as to whether the thick, deep-running branches (*c*) are healthy—and therefore potentially capable of giving rise to further centres of growth—or dying off.

Part II of this paper reports the results of some recent field trials in which such a form of analysis has been used.

Acknowledgment

The author records her appreciation to the Agricultural Research Council for their continued support of these investigations.

References

[1] Watt, A. S., *New Phytol.*, 1940, **39**, 401

[2] Conway, E., & Stephens, R., *N.A.A.S. quart. Rev.*, 1954, (25), 1

Part II. Effects of various Herbicides on Field Bracken (*Pteridium aquilinum*)

by

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Introduction

This paper is a progress report concluding certain experiments reported at the last conference and outlining some recent ones. The trials were in the nature of field screening tests and had two main aims: (1) to study the effects of the various herbicides on the bracken plant, especially the rhizome; (2) to select those worthy of inclusion into field-scale trials for control of bracken under Scottish hill-farming conditions.

Review of chemicals

Since most of the herbicides under trial have been reviewed previously,[1] only the additional ones are mentioned below.

Borates.—A number of boron compounds, especially borax and crude sodium borate, are used in this country for non-selective weed control and soil sterilisation. Applications rates are usually high, and, depending on formulation, vary from 8 to 40 cwt./acre. Borates are not broken down in the soil but are liable to leaching, the rate of which depends on rainfall, soil type, and particle size of the compound.

Borate–sodium chlorate mixtures have been in use for some years, the primary function of the borate being to suppress the fire risk of the chlorate. Liquid formulations of this mixture are also available. In recently devised borate/organic herbicidal combinations, the function of the stable inorganic compound is to inhibit the microbial breakdown of the organic compound, thus prolonging its activity in the soil. Such formulations include 2,4-D or monuron.[2,3]

Borate formulations have been used on bracken and it has been reported that in Wales sodium borate and 2,4-D applied in the spring prevented bracken growth for two years.[3]

Dalapon (2,2-dichloropropionic acid).—Dalapon is principally used as a selective herbicide for the control of annual and perennial grasses,[4,5] and is readily absorbed and translocated through the foliage. Rates of 10–15 lb./acre are used for the control of couch, and results from recent experiments indicate that at rates of 40 lb./acre complete control may be obtained of other rhizomatous plants such as reedmace (*Typha* spp.).[6] Another report states that dalapon applied to bracken in July 1956 at a rate of 20 lb./acre prevented frond growth throughout 1957.[3]

Experimental

General design

Most of the experiments were fully replicated with plot size 5 yd. × 2 yd., but when only small amounts of chemical were available, single-plot experiments were carried out. The trials were at Drumclog Moor, Dunbartonshire (average rainfall 35 in. for 1956 and 1957) where the bracken stand is fairly uniform with a density of 30 fronds/sq. yd. at an average height of 3½–4 ft. when fully mature. Materials were applied in solution at 100 gal./acre, with the exception of some of the borate compounds, for which a mechanical spreader was used.

Method of analysis

The method of analysis was (*a*) rhizome analysis of the state of stem tips and accompanying frond buds after treatment; (*b*) frond counts particularly in the years following treatment to record reduction in density.

Results

I. Final results of 1955–56 trials (previously reported)

(1) *Foliar applications* of the following materials were used: ammonium sulphamate; maleic hydrazide; MCPB (sodium); aminotriazole; 2,4,5-T; aminotriazole and 2,4,5-T in mixture: only aminotriazole at 20 lb./acre and 40 lb./acre produced any visible effect in the year after treatment. There was a reduction in frond density and the emerged fronds were chlorotic, suggesting that the herbicide had been translocated through the rhizome to the following year's developing frond buds. This was the first time in our trials that a translocated herbicide had produced effects in the year after treatment. Severe chlorosis and stunted growth were also noted on various angiospermic species occurring in the plots.

(2) *Soil applications.*—Ammonium sulphamate, trichloroacetic acid, aminotriazole and monuron applied in the spring as soil applications produced no lasting effects and the plots are now densely covered with fronds.

II. Recent trials 1956–58

(1) *Non-selective herbicides*

(a) *Borates.*—The various borate formulations used in the trials were: B44 and NB (sodium borates), DBG (88·5% sodium borate + 7·5% 2,4-D), U.B. (94% sodium borate + 4% monuron), PC (75% sodium borate + 25% sodium chlorate), MC (liquid formulation based on sodium borate and chlorate).

Experiment 1956.—These materials were not available until June and as borate applications act mainly through the soil and are best applied early in the season the experimental site was cut over with a scythe, thus removing the bracken stand. The experiment was a preliminary guide to laying down a replicated trial in the following spring and consequently treatments were single (with the exception of DBG) and rates per 10 sq. yd. were as follows: DBG ¾ lb. and 1 lb., U.B. 1 lb., DBG ½ lb. + ½ lb. U.B., B44 2 lb., 4 lb. and 8 lb., PC 2 lb. and 4 lb., 2,4-D (ester) 8 lb. soil application and also 8 lb. foliar application.

Of these only B44 gave any real control in the year after treatment. The higher rate of 8 lb. on 10 sq. yd. reduced the number of fronds on the plot from 300 to 7 and a rhizome sample bore no live buds.

The creeping soft grass (*Holcus mollis*) was badly scorched after treatment in 1956 but by September 1957 was luxuriant. By 1958, of the other treatments only 4 lb. B44, 2 lb. and 4 lb. PC and the 8-lb. 2,4-D ester as a foliar application showed any real reduction in density (Table I).

Table I

Reduction in frond density, 2 years after treatment with borate formulations

Treatment 1956	% reduction in frond density 1958
8 lb. B44	93
4 lb. B44	58
2 lb. PC	30
4 lb. PC	38
8 lb. 2,4-D (ester) foliar	36

Experiment 1957.—A replicated experiment using various borate formulations was laid down in spring 1957. Treatments per 10 sq. yd. were: 2 lb. DB, 1 lb. and 2 lb. U.B., $\frac{1}{2}$ lb. DBG+$\frac{1}{2}$ lb. U.B., 1 lb. U.B.+1 lb. DB, 2 lb. and 4 lb. PC, 4 lb. and 8 lb. B44. After removal of the previous year's litter the treatments were applied on 4th May just as the croziers were emerging.

A month after treatment only a few fronds were present in all treated plots and these were showing the typical chlorosis of boron toxicity and varying degrees of scorch. Also there was severe epinasty on the DBG plots. Two months later all plots were practically bare but by August showed a flush of fronds, particularly on the U.B. and U.B.+DB plots. By September there were no fronds on the 8-lb. B44 plot and approximately 3 on the 2-lb. and 4-lb. PC and on the 2-lb. DBG plots. In contrast, there were 30 or more fronds on all other treated plots. Rhizome analyses at the end of September 1957 showed that the greatest damage to the lower rhizome was with the B44 and PC treatments where, of 20 lengths of rhizome taken at random, 17–20 were dead or in a moribund condition and, in addition, the stem apices and associated frond buds were rotted away. With the other treatments varying degrees of damage were seen on stem apices and frond buds but the lower rhizome was relatively undamaged. A similar analysis was carried out in October 1958 and, as can be seen in Table II (a), these results are confirmed.

The reduction in frond density by September 1958 (Table IIa) shows that plots treated with 2 lb. and 4 lb. PC and 8 lb. B44 showed no fronds at all, and were practically bare of other vegetation although creeping soft grass and rosebay willow herb were beginning to colonise the plots.

Experiment 1958.—A further series of replicated trials was laid out this spring with DBG, NB and MC. Since it has been reported[8] that 2,4-D is being used in the U.S.A. at high rates for non-selective weed control, rates of 2,4-D (ester) at 40 lb./acre and 80 lb./acre were included.

DGB caused epinasty in a few days. To see whether this was caused by absorption through the soil or foliage, a small plot was laid out and the DBG sprinkled carefully on so that it did not come in contact with emerging fronds. After 2 weeks none of the fronds showed epinasty and the inference is that the material, although granular, must partly adhere to the frond and be absorbed. The same effect was noted with the straight 2,4-D, as only those fronds which received the spray responded. Results so far are preliminary but rhizome analyses carried out in October suggest that, of these treatments, the most effective so far is the chlorate/borate liquid formulation. The high rate of 2,4-D as a soil application produced no real effect on the rhizome.

(b) *Sodium chlorate.*—Experiment 1957. The effect of sodium chlorate on bracken is already known. This trial was to see if it could be applied by mechanical spreader and to compare it with newer non-selective herbicides. Plots were 10 yd. × 2 yd. and single treatments were as follows: 100 lb., 200 lb., 300 lb., 400 lb. and 500 lb./acre were applied on 1st July, 1957. When the bracken was over 3 ft. high a fortnight later all fronds were showing severe scorch.

Rhizome analyses and frond density counts (Table IIb) show that all treatments over 200 lb. were most effective, giving over 97% frond reduction and rhizome kill $1\frac{1}{4}$ years after treatment. Creeping soft grass has gradually re-colonised the bare ground.

Table II

Effects of herbicides on bracken (treated May 1957; analysed October 1958) (treated July 1957; analysed October 1958)

Treatment	Branch apices associated with: Current year fronds — Rhizome tips/20 — Healthy	Dead or dying	Associated frond buds — Healthy	Dead or dying	Not visible	Fronds older than 1 year — Rhizome tips/10 — Healthy	Dead or dying	Associated frond buds — Healthy	Dead or dying	Not visible	Lower lengths of rhizome/20 — Healthy	Dead or dying	% reduction in frond density 1958
(a) *Borates/per 10 sq. yd.* (treated May 1957, analysed Oct. 1958)													
Control	20	—	20	—	1	10	—	9	—	2	18	2	—
2 lb. DBG	4	—	4	—	—	3	7	3	—	7	4	16	59
1 lb. UB	19	1	22	1	2	10	—	11	—	—	14	6	13†
2 lb. UB	20	—	22	—	2	9	1	10	—	1	14	6	9†
½ lb. UB+½ lb. DBG	20	—	21	1	1	7	3	6	—	3	12	8	29
1 lb. UB+1 lb. DBG	20	—	22	—	4	7	3	7	1	3	12	8	43
2 lb. PC	—	20*	—	20*	—	—	10*	—	10*	—	—	20	100
4 lb. PC	—	20*	—	20*	—	—	10*	—	10*	—	—	20	100
4 lb. B44	—	20*	—	20*	—	1	9*	1	9*	—	1	19	71
8 lb. B44	—	20*	—	20*	—	—	10*	—	10*	—	—	20	100
(b) *Sodium chlorate/acre* (treated July 1957, analysed Oct. 1958)													
Control	20	—	20	—	1	10	—	9	—	2	18	2	—
100 lb.	19	1	27	—	3	10	—	8	—	2	10	10	32
200 lb.	10	—	13	—	—	10	—	10	—	—	2	18	75
300 lb.	—	20*	—	20*	—	1	9*	1	9*	—	1	19	98
400 lb.	—	20*	—	20*	—	—	10*	—	10*	—	—	20	100
500 lb.	—	20*	—	20*	—	—	10*	—	10*	—	—	20	97
(c) *Dalapon or aminotriazole* (*ATA*), analysed 8 weeks after treatment (1957)													
Control	20	—	16	1	3	10	—	6	—	4	—	—	—
20 lb. dalapon	20	—	10	—	10	10	—	4	—	6	—	—	—
40 lb. dalapon	19	1	15	—	5	10	—	3	—	7	—	—	—
20 lb. ATA	20	—	13	—	7	10	—	9	—	4	—	—	—
40 lb. ATA	19	1	10	—	10	9	1	6	—	4	—	—	—
10 lb. dalapon+10 lb. ATA	20	—	12	1	7	9	1	4	1	5	—	—	—
15 lb. dalapon+15 lb. ATA	19	1	6	—	14	9	1	5	1	4	—	—	—
(d) *Dalapon or aminotriazole* (*ATA*), analysed 1 year after treatment (1958)													
Control	20	—	16	—	4	11	—	5	1	4	—	—	—
20 lb. dalapon	18	2	16	—	6	10	—	8	1	1	—	—	—
40 lb. dalapon	17	3	15	—	8	9	1	6	1	3	—	—	—
20 lb. ATA	19	1	16	—	6	10	—	9	1	1	—	—	—
40 lb. ATA	20	—	18	—	6	9	1	6	—	4	—	—	—
10 lb. dalapon+10 lb. ATA	18	2	14	—	7	11	—	7	1	2	—	—	—
15 lb. dalapon+15 lb. ATA	20	—	13	—	9	10	—	8	1	1	—	—	—

* Completely rotted away † Increase in density over control

Introduction

In one of the routine experiments laid down by the Unit in 1956 to test the toxicity of new herbicides to bracken, it was found that dalapon (Na) at doses between 10 and 40 lb. acid equivalent (a.e.)/acre gave an appreciable reduction of fronds in the year after spraying. Further investigations have, therefore, been carried out with this herbicide to determine its potential value for the practical control of bracken. The results so far obtained are summarised in this report. The programme has been in two phases, the first carried out by the Unit to determine the best method and time of application, the second in collaboration with the National Agriculture Advisory Service to gain experience of the varied reaction of bracken growing in different situations and localities. All experiments have been sprayed using the commercial product Dowpon containing 85% sodium salt of 2,2-dichloropropionic acid and a wetting agent. No additional wetting agent was added. All doses in this report are in terms of lb. of dalapon a.e./acre. The experiments were of randomised plot design with three replicates.

Experimental and results

I. Experiments carried out by the Unit

Eight experiments have been carried out by the Unit in the neighbourhood of Oxford, the principle object being to investigate the following factors of application that could influence the results: date of application, single dose compared with half-doses at two dates, volume rate and method of application. Counts of bracken were made before spraying as well as in the year following spraying. The pre-spraying counts have not been used in presenting the results because it was found that the density of the control plots often varied from one year to another, in some instances by nearly 70%; also considerable errors were inevitable when counting dense mature bracken. The results have therefore been expressed in terms of the percentage reduction of the population on the control plots at each time of assessment. When the assessment was made, a strip 18 in. wide around each plot was discarded.

Relevant details concerning each experiment are given in Table I. The results are briefly summarised in Tables II–VI.

Table I

Details of experiments carried out by A.R.C. Unit

Expt. No.	Stage of development	Vol. rate, gal./acre	Site
W/32/55	Mature fronds, 3–4 ft.	40	Large unshaded area in woodland.
W/15/57	Fronds not fully expanded, 4–5 ft.	20	Oak wood with more or less closed canopy.
W/17/57	June: Fronds still uncurling, 3–6 ft.	20	Sparsely wooded area in parkland.
	July: fronds fully uncurled, 3–6 ft.	20	
	August: fronds mature, 3–6 ft.	20	
	September: lower pinnae turning brown.	20	
W/18/57	Fronds uncurled but not fully expanded, 3–6 ft.	See Table VI	Sparsely wooded area of parkland.
W/19/57	Fronds still uncurling at apex, 4–6 ft.	See Table V	Sparsely wooded area of parkland.
W/21/57	Fronds still uncurling and expanding, 2–4 ft.	20	Open ride between conifer plantations.
W/24/57	Fronds mature, fully expanded and producing spores, 3–4 ft.	40	Large open area on hilltop.

II. Experiments carried out in co-operation with the National Agricultural Advisory Service

Eleven experiments were sprayed in late July 1957. The lay-out was identical at all sites. Treatments were dalapon at 5, 10 and 20 lb. a.e./acre arranged in randomised blocks (one control per block) with three replicates. The plot size was 4 yd. × 6 yd. with 1-yd. paths between plots. Spraying was carried out in each case with the Oxford Precision Sprayer at a volume rate of 20 gal./acre. The sites varied considerably in aspect and contour and in the height and density of the bracken and the associated vegetation. This information is summarised in Table VII. The bracken in each case was completely unfurled or approached this stage although in no instances had the sporing stage been reached. Spores were, however, just beginning to appear on 1st August at the time of the second spraying at Llandrindod. No pre-spraying counts were made.

Tables II–VI

Effect of dalapon on bracken as assessed during the year after treatment

Results (mean of 3 replicates) expressed as % reduction of fronds compared with control at time of assessment. Plots were generally 4 yd. × 6 yd. and were sprayed by means of the Oxford Precision Sprayer. W/19/57 was sprayed with a Land Rover sprayer and plots were 5 yd. × 20 yd. All experiments were of randomised block design.

Table II

Preliminary experiments on dose-response

(frond density as % reduction of control)

	W/32/55		W/15/57			W/21/57	W/34/57		
Sprayed	14.8.56		6.6.57			7.6.57	28.8.57		% ground cover of bracken
Assessed	27.5.57	3.7.57	19.5.58	8.7.58	27.8.58	8.7.58	5.6.58	8.7.58	8.7.58
Dose, lb./acre									
5	—	—	78	42	—	8	60	31	87
10	76	42	72	40	16	6	90	41	18
20	93	72	97	76	42	0	98	54	7
40	97	92	—	—	—	—	—	—	(Control) 100

Frond density as % reduction of control

Table III

Spraying experiment W/17/57 (i)

(assessed 3.6.58)

Sprayed on	20.6.57	25.7.57	26.8.57	26.9.57
Dose, lb./acre				
5	35	14	30	23
10	38	31	33	20
20	53	76	62	30

Table IV

Split application experiment W/17/57 (ii)

Assessed	3.6.58	8.7.58
Dose, lb./acre		
2·5+2·5 lb.	−18	13
5+5 lb.	41	21
10+10 lb. applied on 21.6.57 and 26.8.57 respectively	71	29

Table V

Volume rate experiment W/19/57

(Land Rover application)

Sprayed 26.6.57, assessed 24.7.58; dose 7·5 lb./acre

Volume rate (gal./acre)	7	22	83	control
% reduction of control at time of assessment	36	47	38	—
% reduction based on pre-spraying counts	−12	−8	−17	−68

Table VI

Volume rate experiment W/18/57

(hand application)

Sprayed 26.6.57, assessed 3.6.58; dose 10 lb./acre

Volume rate (gal./acre)	10	40	80*
% reduction of control	9	26	36

Difference between treatments not significant.

* Application by hand lance at 50 p.s.i.; other treatments applied over-all with a spray boom.

Observations made on some of the trials in the autumn of the year of spraying showed that the treatments were slow in producing visible symptoms, which consisted of scorch of the fronds, and that the higher the dose the greater the scorch.

Results

Counts early in the year following spraying indicated a marked effect of treatment (Table VIII). The lower doses had given widely varying results between different sites but at 20 lb. of dalapon/acre in each instance there was 75% or more reduction of frond density, and even 99% reduction at three sites. Counts taken later in the year showed that an increase in fronds on the treated plots had occurred since the previous assessment. At only two sites was there now a 75% or greater reduction in fronds as a result of treatment with 20 lb. of dalapon/acre. As before, the results varied greatly from site to site. At some sites the density on the treated plots had not changed markedly since the early counts, notably at Otley, whereas at other sites what apparently had been an excellent control at the time of the first count turned out later to be a very poor control; the outstanding example of this is the experiment at Caerphilly.

In order to get some assessment of vigour of the treated bracken the average height was measured and the density of the foliage estimated as the amount of ground not covered by bracken (Table IX). The reduction in height varied greatly between experiments. The highest dose of dalapon gave a reduction varying between 0 and 80%. As might be expected the estimates of ground cover varied from site to site, but in each experiment there was generally a marked dose trend, the higher dose being associated with the least cover of bracken.

Table VII

Conditions at each site at time of spraying

(N.A.A.S. experiments)

Site	Aspect and contour	Height of bracken, ft.	Remarks
1. Ringwood, Hants.	Flat, sheltered on east by wood	3	Rain 1 h. before spraying but foliage dry when sprayed. Sharp shower ½ h. after spraying completed
2. Caerphilly, Wales	Slope with northerly aspect. Open	2	Bracken burnt off previous year and ground blackened at time of spraying
3. Llandrindod, Wales	Steep slope with westerly aspect. Open	4–5	Rain fell within 1½ h. of spraying on 20th July: a duplicate set of plots was sprayed on 1st August
4. Brampton Bryan, Hereford	Steep slope with easterly aspect. On wooded hill	4½–5½	Rain ½ h. before spraying and foliage wet when sprayed. Rain within 1½ h. of completion of spraying
5. Oswestry, Salop	Steep slope with northerly aspect. Open	4–5	
6. Otley, Yorkshire	Level area in small valley in moorland. Open	1	The area had been crushed twice a year, in the preceding three years. This had reduced the bracken in height and vigour but apparently not in density of fronds
7. Stanhope, Co. Durham	Slope with easterly aspect. Open	4–5	
8. Blanchland, Co. Durham	Slight slope with south-easterly aspect. Open	1½–2	Bracken open: kept in check as a result of cutting for bedding
9. Edale, Derbyshire	Steep slope with northerly aspect. Open	2–3	Bracken wet when sprayed: drizzle 1 h. after spraying
10. Mildenhall, Suffolk	Flat. Along lane in arable country	6–7	
11. Woburn, Bedfordshire	Flat in open area of woodland	4–5	

Table VIII

Effect of dalapon on bracken

(Frond counts during year following spraying as % reduction of control)

Site	Ringwood		Caerphilly		Llandrindod (a)*		Llandrindod (b)		Brampton Bryan†		Oswestry†	
Date of assessment, 1958	27/5	11/7	27/5	31/7	29/5	1/8	29/5	1/8	4/6	25/7	5/6	—
Dalapon, lb. a.e./acre												
5	79	14	57	−6	85	27	90	27	14	21	5	18
10	79	25	50	5	98	40	97	31	56	36	32	39
20	93	75	91	7	99	54	99	49	89	53	79	68
Approx. no. fronds on control plots (per sq. yd.)	0·3	13	6	18	10	18	10	15	12	13	11	15
Date of spraying, 1957	12/7		1/8		20/7		1/8		19/7		19/7	

Site	Otley		Stanhope		Blanchland		Edale		Mildenhall		Woburn	
Date of assessment, 1958	11/6	6/8	10/6	8/8	20/6	2/9	5/6	14/8	30/5	—	7/7	4/9
Dalapon, lb. a.e./acre												
5	35	29	11	46	8	−7	88	52	—	—	46	20
10	84	72	76	43	15	3	99	61	56	—	92	65
20	99	91	86	58	75	45	99	71	75	—	97	64
Approx no. fronds on control plots (per sq. yd.)	58	42	9	46	24	22	100	104	6	—	12	12
Date of spraying, 1957	22/7		22/7		23/7		24/7		25/7		25/7	

* Heavy rain followed spraying and duplicate plots sprayed on 1.8.57

† Approximate figures based on an estimated density of control plots

Samples of the bracken rhizomes were taken from each plot at the Edale experiment on 10th October, 1958, the numbers of living rhizome apices and frond buds counted and fresh weights recorded. Results are summarised in Table X. Most of the living apices and frond buds from the plots treated with 20 lb. of dalapon/acre were obviously affected, being markedly swollen and internally discoloured and it is probable that many of them will fail to survive. Consequently the figures given may considerably underestimate the full effects.

Discussion

The results of these experiments show a remarkable variation when assessed during the year following spraying, ranging from no appreciable effect after applying 20 lb. of dalapon/acre

Table IX

Effect of dalapon on height and ground cover of bracken 12 months after spraying

(1) Height expressed as % reduction of control
(2) Ground cover expressed as % of ground area not sheltered by fronds

Dalapon, lb. a.e./acre	Ringwood (1)	Ringwood (2)	Caerphilly (1)	Caerphilly (2)	Llandrindod (a)* (1)	Llandrindod (a)* (2)	Llandrindod (b) (1)	Llandrindod (b) (2)	Brampton Bryan (1)	Brampton Bryan (2)	Oswestry (1)	Oswestry (2)
5	16	7	25	13	13	5	31	5	0	7	10	—
10	25	33	39	17	20	15	27	10	12	15	33	—
20	46	88	57	53	43	47	47	50	45	40	50	—
Control	—	3	—	10	—	0	—	0	—	2	—	—
Date of assessment, 1958	11/7		31/7		1/8		1/8		25/7		—	

Dalapon, lb. a.e./acre	Otley (1)	Otley (2)	Stanhope (1)	Stanhope (2)	Blanchland (1)	Blanchland (2)	Edale (1)	Edale (2)	Mildenhall (1)	Mildenhall (2)	Woburn (1)	Woburn (2)
5	33	35	0	42	16	27	40	—	—	—	2	7
10	53	84	16	45	13	27	60	—	0	0	33	52
20	80	97	46	58	5	58	80	—	0	0	38	58
Control	—	8	—	32	—	13	—	—	—	—	—	0
Date of assessment, 1958	6/8		8/8		2/9		14/8		5/9		4/9	

* see Table VIII

Table X

Effect of dalapon on rhizomes 14 months after treatment

(Experiment at Edale)

Sample per plot=3 sq. ft. (figures are mean of 3 replicates)

Dalapon, lb. a.e./acre	Number of living rhizome apices	Number of living frond buds	Fresh weight of rhizomes, lb.	oz.
5	86	78	2	12
10	68	61	3	5
20	48	40	1	14
Control	84	89	3	11

to a 90% reduction of fronds being maintained throughout the growing season. Most of the experiments were sprayed at one time of the year with a standardised technique of application, and the variation cannot therefore be attributed to these factors. The experiments designed to find out whether date or method of application are important factors influencing the effect of dalapon on bracken have failed to give accurate information, but even so it seems that an explanation for the varied results must be sought elsewhere. The most successful results were obtained at a site (Otley) where the bracken had been crushed twice a year during the three years preceding the dalapon treatment; this is the only site reported to have received management of this kind. Apart from this, there is no hint of why results should have been different at the various sites.

Of particular interest are the experiments in Blenheim Park (W/17–19/57). Four experiments, including a wide range of treatments, were laid down within an area of 200 yd. × 50 yd. of what appeared to be uniform bracken. Counts of fronds in the control plots before treatment compared with similar counts made the following year are given in Table XI.

Table XI

Variation in frond density of control plots, Blenheim

Experiment No.	Density, fronds/sq. yd. 1957	1958
W/17/57 (i)	13	21
W/17/57 (ii)	13	12
W/18/57	11	4
W/19/57	9	14

With such variation of the untreated frond populations it cannot be expected that experiments of the type described, in which assessments have been confined to recording frond densities, will allow accurate comparison of treatments, although they are useful for assessing over-all effectiveness. The value of assessing the effects of herbicide treatment of bracken by examination of the rhizomes has been emphasised by Conway & Forrest[1] and there is no doubt that much valuable information would have been obtained if more analyses of rhizomes of the kind done by McIntyre[2] for the Edale experiment had been carried out.

The response of bracken to dalapon appears to be similar to that observed for *Agropyron repens* and other creeping perennial grasses:[3] death of aerial growth followed by a dormancy of the rhizome buds which may or may not be permanent according to the dose of dalapon applied, the environmental conditions and other factors. Regrowth from temporarily dormant bracken rhizomes is illustrated in the histogram (Fig. 1).

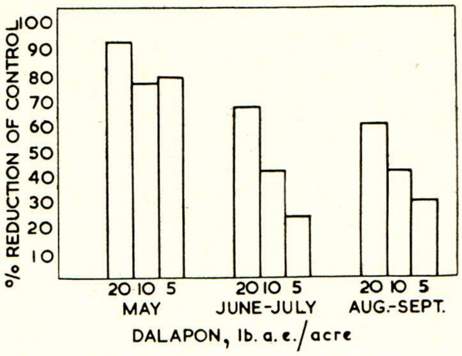

FIG. 1. *Dalapon on bracken, 1956–58*
% reduction of control based on frond counts during the year following spraying (mean results of 18 experiments)

Conclusion

From these results it is clear that dalapon at doses up to 20 lb./acre is unlikely to eradicate bracken, but that a marked suppression of frond density and vigour can often be obtained, the effect increasing with the dose applied. It remains to be seen whether dalapon applied in two successive years can eradicate bracken and experiments with this in view are already in progress.

Acknowledgment

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References

[1] Conway, E., & Forrest, J. D., *Proc. 3rd Brit. Weed Control Conf., 1956*, p. 255

[2] McIntyre, G., personal communication, 1958

[3] Fryer, J. D., & Chancellor, R. J., *Proc. 4th Brit. Weed Control Conf., 1958*, p. 197

GRAZING OF BRACKEN *(PTERIDIUM AQUILINUM)* BY SHEEP IN SOUTH WALES

by

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Bracken has been locally heavily grazed, to the point of near or complete destruction, by sheep in several localities. The phenomenon is described from observations made over the past four years.

Introduction

Large areas of bracken occur on most hill sheep grazings in Wales. Sheep do not normally graze the fern beyond taking a casual bite occasionally, and where the bracken is so strong as to eliminate other species, healthy sheep rarely penetrate it. Over the last four years, however, several cases have come to our notice where obvious and severe grazing of dense fern by sheep is taking place, causing the weakening or eventual destruction of the bracken. In 1954, a farmer informed Brecon N.A.A.S. officers that areas of bracken on his sheep-run at Llangynog on Mynydd Eppynt common had been dying off. Soon after, a similar phenomenon was reported