THE EFFECT OF MCPA, MCPB AND 2,4-DB ON THE PRODUCTIVITY AND BOTANICAL COMPOSITION OF PERMANENT PASTURE

by

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(1) The use of selective weedkillers normally gave a satisfactory control of *Ranunculus repens* and *Cirsium arvense* in permanent pasture without affecting the production of green matter of that pasture.

(2) Under the type of management practised in these trials MCPA was a better weed-killer than MCPB or 2,4-DB.

(3) For any quantity of weeds in the pastures investigated the production of grass and clover was reduced by a similar amount.

(4) The method of assessing productivity used in the trial (green weight and % of dry matter in a mown sample) did not bring out fully the advantages obtained from successful weed control. The management of the pasture and the grazing animal as a factor in this will have to be taken into account.

(5) It is necessary in productivity work of this type to take samples of cut herbage and to separate out the weeds from the grass and clover to determine what proportion of the total production is made up of weeds.

(6) The use of silage cuts for two years as a means of assessing the productivity of a sward is not suitable as it severely reduces the amount of clover present.

Introduction

Four trials were carried out during 1956 and 1957, designed to study the effect of MCPA, MCPB and 2,4-DB on botanical composition and productivity of permanent pasture.

Experimental

The trials were laid down in 1956 and continued in 1957. Two trials were on pastures infested with creeping buttercup (*Ranunculus repens*) while in the other two creeping thistle (*Cirsium arvense*) was the main weed. In the trials, one spraying only was made, in 1956, with (1) MCPA, 12 and 24 oz.; (2) MCPB, 24, 30 and 36 oz.; (3) 2,4-DB, 24, 30 and 36 oz. (all acid equivalent/acre). Application was made with an Oxford Precision Sprayer calibrated to deliver 19 gal./acre. Each trial consisted of four replicates. The 1/200 acre (2 yd. × 12 yd.) plots were randomised within the replicate with a yard path between them. The whole trial area was fenced against stock.

The botanical composition of the sward was assessed by an eye estimate of the percentage ground cover of grass, clover and weeds in three 1-yard-square, fixed quadrats per plot. The data recorded are the means of the assessments of two observers.

Productivity was measured by taking a cut with an Allen Autoscythe through the middle of each plot. Two cuts were taken from each trial in both years and the green weight recorded. The percentage dry matter from each plot was obtained from sub-samples and at the second cut each year crude protein analyses were carried out. During 1957 a further sub-sample was separated into grass, clover and weeds and the percentage of these constituents recorded.

Results

Trials on Ranunculus repens

The first spraying was done on 8th May, 1956, and the first cut taken on 5th June. Following this cut the *Ranunculus* spp. disappeared and the main constituent of the sward besides grass and clover was *Achillea millefolium*. A second cut was taken on 11th September, when the *Ranunculus* spp. were returning and subsequent assessments showed that the untreated plots contained a higher percentage of weeds than the treated ones, MCPA at 24 oz./acre giving the best control. (The productivity assessments showed no significant difference between the green weights, dry matter or crude protein analyses at either cut.) In the second year, prior to the first cut in May, assessments of the ground cover during the previous month showed that the untreated plots had more weed and less grass than the

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sprayed ones. No significant differences were observed in the green weight and percentage dry matter at this cut. Separation of weeds from grass and clover in sub-samples indicated that the untreated control had a significantly higher percentage of weeds than with the MCPA, MCPB and the 30 oz./acre 2,4-DB treatments (Table I).

At the second cut no marked differences were recorded in green weight, dry matter percentage, crude protein analyses or in the percentage of weeds and grass in the separated sub-samples.

During the whole of the second year clover had practically disappeared from all the plots in the trial area.

The second spraying in the *Ranunculus* trial was on 14th May, 1956, and the first cut taken four weeks later. No significant differences were obtained from the productivity figures of this cut.

Ranunculus spp. became dormant in the summer and *Taraxacum officinale* became the main weed. During the summer, ground cover assessments showed that all the sprayed plots had significantly less weeds and more grass than the untreated. The second cut was taken on 18th September when the green weights from plots treated with MCPA at 12 oz. and MCPB at 30 oz./acre were significantly higher than those from the untreated plot and those treated with MCPB at 24 oz. and 2,4-DB at 24 and 36 oz./acre. The dry matter percentage and crude protein analyses showed no marked differences (Table II). The *Ranunculus* spp. returned in the autumn and all treated plots showed a significant weed control relative to the untreated.

In the second year, as in the previous trial, practically all the clover disappeared from the trial plots. During the spring all sprayed plots had less weeds and more grass than the untreated, MCPA at 24 oz./acre being the most effective treatment. No significant differences were found in the green weights or dry matter percentages from the first cut. Separation of weeds from grass and clover showed that the untreated samples had a higher weed content than any from the treated plots except MCPB at 24 and 30 oz./acre.

Throughout the summer untreated plots had a higher percentage ground cover of weeds and less grass than the treated except for the lowest rate of MCPB. MCPA gave the best weed control throughout.

At the second cut green weight, dry matter percentages and crude protein analyses were similar from all plots. Separation showed that samples from the untreated plots had a higher percentage of weeds than those treated with MCPA and 2,4-DB at 30 oz., while the MCPA 24-oz. samples had less weeds than those from MCPB 24-oz. and 30-oz. and 2,4-DB 24-oz./acre (Table III).

Cirsium arvense (*Creeping thistle*) *trials*

In these two trials the butyrics were applied when the thistles were between 4 to 8 in. high and the MCPA was applied at the 'tight bud' stage.

The first trial was cut 17 days after the MCPA application and no significant differences were found in green weights or percentage dry matter. By the middle of August all the treated plots had a significantly higher percentage of grass than the untreated ones. The second cut was taken at the beginning of October and the green weight, dry matter percentage and crude protein analyses were similar from all plots. The final ground cover assessment of the year showed little difference between any treatments including controls.

By the middle of April in the following year the untreated plots had less grass and more weeds than the treated ones, but the results from the cuts taken in May showed little difference in the green weight and dry matter percentage from the various treatments. Separation of sub-samples showed that there was a higher percentage of weeds in those from untreated than from treated plots.

Throughout the summer, assessments of the botanical composition of the sward showed that all treatments had given a significant control of weeds. The final cut was taken at the beginning of September and once again no significant difference in green weight, percentage dry matter or crude protein analyses was found. A higher percentage of weeds was found in the separated samples from untreated plots than from all treated ones except 2,4-DB at 30 oz./acre (Table IV).

Botanical composition and productivity

Table I

Ranunculus trial No. 1, 1957

Date	Type of Assessment		MCPA 12 oz.	MCPA 24 oz.	MCPB 24 oz.	MCPB 30 oz.	MCPB 36 oz.	2,4-DB 24 oz.	2,4-DB 30 oz.	2,4-DB 36 oz.	Control	C. of V.	Significant difference 5·0%	1·0%	0·1%
1.4.57	% Ground cover	Grass	88·95	96·85	89·35	90·30	93·10	88·10	89·10	82·20	66·50	4·57	5·66	7·62	10·15
		Clover	0·25	0·35	0·15	0·20	0·30	0·30	0·20	0·10	0·40	—	—	—	—
		Weed	10·80	2·80	10·50	9·45	6·60	11·60	10·70	17·70	33·10	31·40	6·72	9·08	12·09
7.5.57	Productivity	Green wt., lb.	42·2	44·5	44·1	41·5	44·6	43·5	44·9	43·2	43·3	8·48	N.S.	N.S.	N.S.
		% Weed in sub-sample	0·6	0·8	1·9	1·9	1·1	2·9	1·3	2·9	5·4	3·1	2·7	3·6	N.S.

Table II

Ranunculus trial No. 2, 1956

Date	Type of Assessment		MCPA 12 oz.	MCPA 24 oz.	MCPB 24 oz.	MCPB 30 oz.	MCPB 36 oz.	2,4-DB 24 oz.	2,4-DB 30 oz.	2,4-DB 36 oz.	Control	C. of V.	5·0%	1·0%	0·1%
7.8.56	% Ground cover	Grass	86·9	91·0	61·4	67·0	67·8	74·1	68·5	79·9	43·7	8·8	9·2	12·4	16·5
		Clover	5·9	5·2	12·3	10·2	13·8	11·7	18·0	11·5	12·0	42·0	7·0	N.S.	N.S.
		Weed	7·2	3·8	26·3	22·8	18·4	13·9	13·5	8·6	44·3	28·4	8·1	11·3	15·1
18.9.56	Productivity	Green wt., lb.	32·94	31·34	28·53	30·47	32·75	29·62	30·84	29·53	29·55	6·6	2·95	N.S.	N.S.

Table III

Ranunculus trial No. 2, 1957

Date	Type of Assessment		MCPA 12 oz.	MCPA 24 oz.	MCPB 24 oz.	MCPB 30 oz.	MCPB 36 oz.	2,4-DB 24 oz.	2,4-DB 30 oz.	2,4-DB 36 oz.	Control	C. of V.	5·0%	1·0%	0·1%
3.4.57	% Ground cover	Grass	91·8	98·4	76·3	78·4	84·1	87·4	86·2	86·35	64·4	9·3	11·0	12·2	19·8
		Clover	0·4	0·1	0·3	0·25	0·3	0·2	0·3	0·4	0·5	—	—	—	—
		Weeds	7·8	1·5	23·4	21·35	15·6	12·4	13·5	13·25	35·1	41·7	10·8	14·6	19·5
14.5.57	Productivity	Green wt., lb.	39·8	40·6	37·9	44·9	39·3	37·6	35·9	40·1	42·2	9·5	N.S.	N.S.	N.S.
		% Weed in sub-sample	0·4	0·5	3·2	4·3	2·3	1·7	1·8	2·3	6·7	79·0	2·9	N.S.	N.S.
8.8.57	% Ground cover	Grass	84·2	97·1	61·2	71·8	72·2	68·4	74·8	76·8	49·6	12·6	12·9	17·5	23·3
		Clover	0·2	0·0	0·2	0·0	0·2	0·2	0·1	0·0	0·5	—	—	—	—
		Weeds	15·6	2·9	38·6	28·2	27·6	31·4	25·1	23·2	49·9	30·9	13·1	17·7	23·6
28.8.57	Productivity	Green wt., lb.	24·9	27·1	25·6	26·5	29·2	26·3	30·0	28·9	27·6	6·7	N.S.	N.S.	N.S.
		% Weed in sub-sample	3·8	0·6	7·6	8·0	5·1	8·2	3·6	5·7	11·9	70·7	6·8	N.S.	N.S.

Table IV

Cirsium arvense trial No. 1, 1957

Date	Type of Assessment		MCPA 12 oz.	MCPA 24 oz.	MCPB 24 oz.	MCPB 30 oz.	MCPB 36 oz.	2,4-DB 24 oz.	2,4-DB 30 oz.	2,4-DB 36 oz.	Control	C. of V.	5·0%	1·0%	0·1%
8.4.57	% Ground cover	Grass	92·9	94·1	94·4	94·4	94·7	93·2	94·5	96·4	89·3	1·96	2·7	3·6	4·8
		Clover	0·2	0·0	0·1	0·2	0·1	0·1	0·1	0·1	0·1	—	—	—	—
		Weeds	6·9	5·9	5·5	5·4	5·2	6·7	5·4	3·5	10·6	2·88	2·8	3·8	5·1
21.5.57	Productivity	Green wt., lb.	57·3	57·5	56·3	62·8	55·8	54·9	59·2	60·1	56·8	6·4	N.S.	N.S.	N.S.
		% Weed in sub-sample	3·1	1·6	1·6	3·5	1·4	2·0	3·2	2·3	8·2	86·1	4·4	5·9	N.S.
12.8.57	% ground cover	Grass	93·7	91·6	95·0	95·1	92·2	94·0	93·7	96·3	85·3	26·8	3·6	4·8	6·4
		Clover	0·3	0·1	0·1	0·3	0·2	0·2	0·1	0·0	0·2	—	—	—	—
		Weeds	6·0	8·3	4·9	4·6	7·6	5·8	6·2	3·7	14·5	40·9	4·5	6·1	8·1
3.9.57	Productivity	Green wt., lb.	25·6	26·5	27·5	27·7	26·2	26·0	26·0	26·3	27·0	8·7	N.S.	N.S.	N.S.
		% Weed in sub-sample	2·9	3·7	3·6	1·6	3·6	3·6	5·6	2·7	9·7	40·1	2·9	N.S.	N.S.

N.B.—Analyses of actual percentages are given to save space. Angular transformation analyses on a number of assessments indicates that the main differences are adequately brought out by analyses of the percentages. N.S. = not significant.

In the second trial concerned with *Cirsium arvense* the first cut was taken two weeks after the application of MCPA. There was little difference between the green weight and dry matter percentages from the various treatments.

By early September all chemical treatments except MCPB at 24 oz./acre had given a significant reduction in the percentage ground cover of all weeds. At the second cut in early October there were no marked differences in the green weights, dry matter percentages or crude protein analyses obtained from the treatments including controls. Subsequent assessments of the botanical composition of the sward did not reveal any significant differences.

There were very few thistles present in any plot during the second year, nor was there much clover present. No significant differences were recorded at any assessment of the ground cover of grass, clover and weeds.

Two cuts were taken during the second year and no marked differences were found at each cut either from the productivity results obtained, or in the amount of weeds in the separated sub-samples.

Discussion

This series of trials was carried out on 3rd-grade permanent pasture[1] which generally has a high percentage of weed, a mixed population of grasses and a small proportion of clover. This type of pasture probably offers the biggest potential outlet for weedkillers in British grasslands.

The estimation of productivity, by taking cuts at the silage stage, was carried out in the hope that the cuts would not unduly affect the weeds, and that they would not have an adverse effect on the clovers. Unfortunately it was found that this practically eliminated the clover from the plots in the second year. It was, therefore, impossible to obtain data on the effect of the butyric compounds relative to MCPA on the clover in the sward. The cutting-only technique has, therefore, proved to be unsatisfactory for this type of work. Any future investigation will have to take more account of the management of the pasture and will in all probability have to bring in the grazing animal as a management factor even if it is not used as a means of measuring productivity.

It would seem that there may be a case for research into the effect of management on a sprayed pasture in order to determine how a proper balance of grass and clover may be obtained and maintained. Having thus obtained a pasture similar in botanical ground cover analysis to the best type of permanent pasture, the productivity could be examined comparing an improved pasture with an unimproved one.

The results from the trials reported indicate that at the end of the first year the chemical treatments had given a satisfactory weed control when assessed on a percentage ground cover basis of grass, clover and weed. MCPA had given the best control of weeds and there appeared to be little difference in the efficiency of MCPB and 2,4-DB for the control of *Ranunculus repens* and *Cirsium arvense*. There was also an increase in the percentage ground cover of grass following satisfactory weed control.

The productivity figures showed that, in spite of the weed control obtained by the chemical treatments, there was no significant difference in the total amount of herbage obtained from any of the plots. In only one case, the second cut in the first year from a *Ranunculus repens* trial, was there an increased yield. In view of this it was decided to take sub-samples from the grass and clover to determine what proportion of the total weight was in fact weed. The results indicated that where the ground cover analyses had shown a significant decrease in the weed population, the separation showed that there was less weed in the herbage sample, from the corresponding treatments relative to the untreated samples. Thus, although the production from the sward was not materially affected by the use of hormone weedkillers, the proportion of grass was higher where there had been a satisfactory weed control.

References

[1] Stapledon, R. G., & Davies, W., 'Ley Farming', 1941, p. 23 (London: Penguin Books Ltd.)

AN EXAMPLE OF THE RELATION BETWEEN PALATABILITY OF PASTURES AND SELECTIVE BUTTERCUP CONTROL

by

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The results of one experiment on a buttercup-infested pasture are presented, showing a close correlation between the degree of buttercup control at a range of dosages of four different growth-regulating herbicides and the degree of selective grazing by a herd of beef cattle.

Introduction

The objective of selective weed control in pastures is to increase their productivity of milk or meat per unit area. While it is self-evident that the control of a dense infestation of tall weeds such as thistles and rushes will increase the productivity of a pasture, this is not necessarily the case where weeds such as dandelions, daisies and buttercups are concerned.

The ultimate proof for the importance of controlling such weeds can only be obtained from properly controlled grazing experiments where the response to weed control is expressed in terms of milk or meat produced. Such experiments are difficult to conduct and veiy costly. A large-scale grazing experiment of this type was started at Chesterford Park in 1954 but had to be abandoned because of severe drought damage to the grass and clover population in this experiment.

It is a well-known fact that cattle and horses try to avoid buttercup-infested parts of a pasture if they can find a piece of pasture free of this weed. The degree by which this preference is correlated with the density of buttercup infestation has never been closely studied. It was a coincidence that a weed control experiment with the logarithmic sprayer, which was laid out to give information on the relative degree of buttercup control after spraying MCPA, 2,4-D, MCPB and 2,4-DB, enabled us to obtain fairly accurate information on the correlation between buttercup control and selective grazing.

The results obtained have some limitations but it was thought worth while to present the results, as a contribution to a subject on which published evidence is negligible.

Experimental

A weed control experiment was laid out in 1956 on an old permanent pasture of approximately 20 acres, which had an estimated 50% growth cover of bulbous buttercup (*Ranunculus bulbosus*); the main grasses present were Agrostis and Festuca species. Spraying was carried out at the end of May 1956 using the Chesterford Logarithmic Sprayer. MCPA, 2,4-D, MCPB and 2,4-DB were sprayed in two replications, each starting with a peak dosage of 32 oz. acid equivalent for MCPA and 2,4-D and 64 oz. acid equivalent for MCPB and 2,4-DB. Plot width was 15 ft. and the dosage decreased logarithmically along the plot to $\frac{1}{8}$ of the peak dosage.

Approximately one year after spraying, in June 1957 when assessing the degree of buttercup control, it was noticed that the beef cattle grazing on the pasture had concentrated their grazing on the small area of the experimental plots which comprised only 0·04% of the pasture. There were 44 beef cattle at that time feeding on the 20-acre pasture. On close inspection it appeared quite clearly that the intensity of grazing along the logarithmically sprayed plots decreased as the degree of buttercup control decreased. The selective grazing was so accurate that untreated strips about one yard wide between the treated plots were not touched by the cattle; the border line between sprayed and unsprayed plots being clearly marked.

The visual correlation between grazing intensity and degree of buttercup control was very obvious. An attempt was made at an accurate assessment of this correlation. The degree of buttercup control was assessed by counting the number of buttercups on an area of 12 sq. ft. every 3 yards along the logarithmic plots. Corresponding figures showing the degree of grazing were obtained by cutting and weighing the total herbage every 3 yards along the plot and expressing the figures obtained as a percentage of an equivalent untreated control area.

Results

The results, both degree of buttercup control and degree of grazing, are shown in the following table. The correlation coefficient was calculated on all figures disregarding the individual chemicals, showing a highly significant correlation between the two factors.

	MCPA		2,4-D			MCPB		2,4-DB	
Dosage, oz./acre	Grazing, %	Weed control, %	Grazing, %	Weed control, %	Dosage, oz./acre	Grazing, %	Weed control, %	Grazing, %	Weed control, %
32–22	91·7	100·0	80·2	98·5	64–45	91·1	93·9	82·0	95·4
22–16	89·6	100·0	87·1	89·3	45–32	93·5	97·0	90·7	100·0
16–11	91·9	100·0	59·8	67·9	32–22	85·1	93·9	83·8	92·4
11–8	83·7	98·5	55·6	68·0	22–16	50·1	83·2	75·9	93·9
8–6	63·1	89·4	38·7	5·3	16–11	36·3	83·2	44·8	78·6
6–4	69·6	63·3	49·4	28·2	11–8	23·2	26·7	9·4	46·5

Correlation coefficient, calculated on all figures disregarding chemicals = 5·747
Significance of correlation coefficient higher than 99·99%

THE CONTROL OF WEEDS IN PERMANENT PASTURE BY MCPA AND THE SUBSEQUENT EFFECT ON HERBAGE PRODUCTIVITY

(AN INTERIM REPORT)

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The effect of controlling weeds in a permanent pasture, by spraying with MCPA, on the production of the different sward constituents was investigated for two seasons. MCPA was effective in suppressing *Ranunculus repens*, *R. acris*, and various Compositae species. The clover content was slightly reduced by spraying but this reduction was temporary.

Spraying alone did not markedly affect the total herbage production of the sward but the application of nitrogen had a much greater effect. Nitrogen alone increased the total herbage yield and was only slightly more effective where weed species had been controlled by spraying: yield of grass and clover, however, was increased slightly by spraying, much more by nitrogen and most by both spraying and applying nitrogen.

Introduction

There is still a considerable acreage of permanent pasture in the United Kingdom which, for a variety of reasons, is unlikely to be ploughed in the near future. Although a small proportion of this is of a high feeding value, the majority is dominated by inferior grasses and frequently infested with dicotyledonous weeds. Many of these weeds can now be eradicated by chemical treatments, but little work has been done, under practical conditions, to determine the effect of removing the dominant weeds on the long-term productivity of permanent pastures.

A report from New Zealand[1] indicated that when the nutritive value of pasture is related to grass/clover balance, as in lamb fattening, the damage caused to clovers by the use of MCPA and 2,4-D, although temporary, can cause a serious long-term productive loss. There appears to be no published work relating to the British Isles.

Ranunculus repens and *R. acris* are two weeds which can be controlled well by MCPA and the object of the experiment was to investigate the long-term effects of spraying a permanent pasture infested with these species. Total herbage yield and botanical composition have been studied for two seasons after spraying, both in the presence and in the absence of applied fertiliser nitrogen.

It is planned to continue the present measurements for a further one or two seasons and it is hoped that this will be the first of a series of trials in which the long-term effects of controlling various weeds under a wide range of practical conditions will be investigated.

Experimental

The site was an old pasture near Oxford, and the sward contained perennial ryegrass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*), white and red clover (*Trifolium repens* and *T. pratense*) with varying amounts of *Festuca rubra, Poa trivialis, Agrostis stolonifera, Holcus lanatus* and *Deschampsia caespitosa.* The predominant dicotyledonous weed species was *Ranunculus repens*; in addition *R. acris, Taraxacum officinale* and various *Crepis* species were present.

There were four different treatments:

1. Unsprayed, no nitrogen.
2. Unsprayed+6 cwt. of Nitro-Chalk/acre/annum.
3. Sprayed, no nitrogen.
4. Sprayed+6 cwt. of Nitro-Chalk/acre/annum.

The plot size was 30 yd. × 20 yd. and there were two randomised blocks. The spraying treatment was 24 oz. acid equivalent of MCPA/acre in 22·4 gal. of water and was applied on 8th May, 1957. The Nitro-Chalk was applied in two dressings each of 3 cwt./acre. The dates of nitrogen application were 14th May and 25th July, 1957, and 16th April and 9th July, 1958. At the beginning of the experiment a uniform dressing of 54 lb. of P_2O_5 and 54 lb. of K_2O/acre was applied to all treatments. All plots received similar grazing management; from May to September beef cattle, on free range within the field, had continuous access to all plots.

Herbage samples were taken at intervals, with an Allen Autoscythe, from areas protected by cages, there being five cages per plot. Each cage was moved after sampling to a new pre-trimmed area within the appropriate treatment. At each of the sampling dates, sub-samples were separated into grasses, clovers, *Ranunculus* and other weed species.

Pre- and post-spraying assessments of the weed and clover contents were also carried out by the 'specific frequency' method; a 3-in.-square frame being thrown 50 times in each plot and every time a species was recorded within the frame it was given one mark.

Results

Herbage yields

The total yields during 1957 for all the species combined are given in Table I together with the total yields from May to August, 1958. Spraying alone tended to reduce herbage yields when compared with the control. All plots which received nitrogen gave increased yields; during 1957 the response was about 2 cwt. of dry matter for each cwt. of Nitro-Chalk.

Botanical analysis and yields of individual species

In 1957 spraying was very effective in reducing the frequency of *Ranunculus repens* in the sward whether nitrogen was applied or not (Table II), and the total yield of the *Ranunculus* species was also appreciably reduced by spraying (Table III). In the absence of nitrogen, spraying reduced the yields of *Ranunculus* to one-seventh of the control treatment. The specific frequency and total yields of Compositae were also reduced by spraying (Tables II and IIIa). The clover content was less affected by spraying, there being only a negligible reduction in the specific frequency of clover and although the yield of clover was slightly

Table I

Effect of spraying and nitrogen application on the yield of herbage from a permanent pasture
(dry matter, lb./acre)

	Control	MCPA	Nitrogen	MCPA+ nitrogen	Standard error
6th June, 1957	1470	1420	1710	1950	±203
25th July, 1957	1820	1700	2280	2030	±115
28th Aug., 1957	1360	1220	1840	1880	± 72
24th Oct., 1957	660	680	760	940	± 25
Total 1957	5310	5020	6590	6800	±300
27th May, 1958	2710	2520	3420	3420	±161
9th July, 1958	1530	1430	1690	1440	± 87
27th Aug., 1958	1640	1430	2320	2380	±163
29th Oct., 1958	1120	1260	1400	1560	± 71
Total 1958	7000	6640	8830	8800	±300

reduced by spraying, this reduction was relatively much less than the reduction of *Ranunculus* or Compositae. Nitrogen alone increased the yields of grasses more than spraying alone, whilst the combination of spraying and nitrogen application had a very marked effect causing an increase in grass yield, compared with control, of 1990 lb. of dry matter per acre.

The yields of the different constituents of the sward on the first two sampling dates in 1958 are given in Table IIIb. Compared with the control, *Ranunculus* produced slightly less herbage on the nitrogen treatment and considerably less on the sprayed treatments, and was almost totally eliminated when spraying was accompanied by the application of nitrogen. The amount of the various Compositae species was reduced by spraying but not to the same extent as in the case of *Ranunculus*. Clover yields appeared to be slightly reduced by either spraying or nitrogen. The yields of grasses were apparently unaffected by the spraying treatment but were substantially increased as a result of nitrogen applications.

Table II

Specific frequency (per 50×3 in. quadrats) of the occurrence of weeds and clover in the sward during 1957

Species	*Ranunculus repens*			*Ranunculus acris*			*Trifolium repens*			Compositae		
Sampling date	7 May	31 July	21 Oct.	7 May	31 July	21 Oct.	7 May	31 July	21 Oct.	7 May	31 July	21 Oct.
Control	30	25	21	12	4	3	40	41	36	24	15	14
Nitrogen	30	22	21	14	2	2	40	38	34	21	24	22
MCPA	29	7	4	17	0	0	36	41	30	20	14	12
MCPA+nitrogen	32	5	5	14	0	0	42	42	30	20	10	11

Table III

Total yield of the different constituents of the sward
(dry matter, lb./acre)

	(*a*) 1957				(*b*) 1958			
Treatment	Control	MCPA	N	MCPA+N	Control	MCPA	N	MCPA+N
Grasses	4120	4460	4940	6110	6050	6170	7970	8520
Clovers	520	360	600	410	250	180	130	110
Ranunculus spp.	420	60	360	110	470	70	260	10
Compositae	250	140	690	170	230	220	690	160
Total	5310	5020	6590	6800	7000	6640	8830	8800

Discussion

At the start of this experiment the sward was patchy in growth owing to the management it had received in previous years. It had obviously been undergrazed at times, which resulted in a coarse tufted sward. Throughout the experiment the field continued to be undergrazed and the stock tended to be selective in their grazing. The nitrogen plots were grazed more uniformly and tightly than the no-nitrogen plots, and the sprayed plots tended to be grazed slightly harder than the unsprayed plots: it is probable that the more intensive grazing had beneficial effects in addition to those of spraying and nitrogen application. The results obtained must be influenced by the management of the field, and it is to be expected that different management conditions would have led to different results. If better grazing plus topping had been imposed, still better responses and more rapid botanical improvement of the sward might have been obtained.

The improvements shown in the production of grasses and clover indicate the advantages that, under certain conditions, it is possible to gain from spraying combined with the use of nitrogen. No attempt has been made to show how this improvement may be utilised.

During the *first year* of the experiment the most obvious effects were the increased herbage yield on the plots which received nitrogen, and a decrease in the quantity of both *Ranunculus* spp. and Compositae as a result of spraying. There was, therefore, a variation in the yields of the individual species which contributed to the total production of the sward. A better evaluation of the treatments is obtained by considering only the combined yields of 'useful' species (grass and clover). Nitrogen alone increased the yield of grasses plus clover by 900 lb. of dry matter per acre; spraying alone increased it by 180 lb., whilst nitrogen and spraying together increased the yield by 1880 lb. of dry matter per acre. It appears therefore that the best treatment was the combination of both spraying and nitrogen. Presumably grasses were able to benefit from additional nitrogen to a greater extent when the competition of some of the weeds had been removed.

The deleterious, and often lasting, effects that MCPA or 2,4-D may have on established white clover has been noted elsewhere.[2] In the present experiment the clover content of the sward was slightly affected by spraying in the early stages of the experiment, but by 28th August, 1957, the clover content of the sward (by weight) varied only between 7 and 10% on the different treatments.

During the *second season* the nitrogen treatment was again the only one which had an obvious effect on the total yield of the sward, but once again if the individual sward constituents are examined in detail it is apparent that there was still an effect as a result of the previous year's spraying. Spraying alone had resulted in a somewhat lower total production than the control treatment. However, the combined yields of grass and clover were approximately equal on these two treatments. In this connexion it is interesting to note that a decrease in the proportion of weeds had not been balanced by an increase in the yields of either grass or clover. Only when spraying was followed by top dressing of nitrogen was there any increase in the yield of grasses. In the second year the *Ranunculus* species had almost totally disappeared from the plots subjected to this treatment. The Compositae species were a little more resistant to the spraying treatments.

The unsprayed plots, particularly in the early summer of each year, appeared to be very heavily infested with weed species, and this was shown by the specific frequency assessments (Table II). The contribution of the weed species to the total herbage yield was lower than might have been anticipated and the *Ranunculus* species never contributed more than 10% of the dry weight.

This figure, however, may not be a true reflection of the total amount of wasted grazing. *Ranunculus repens* may be very lightly grazed and *R. acris* seldom, if ever, and in avoiding the grazing of these weeds considerable wastage of grasses might occur. Also, in spite of their low yields the weed species, when present, appeared to have a depressing effect on grass production, for it was not until the weeds were controlled that the grasses gave the maximum response to fertiliser application.

When weeds have been eradicated from swards under certain conditions they may be replaced by poor grasses such as *Agrostis* spp. and *Holcus* spp. so that the productivity may not in fact be improved. In addition clover is checked by certain sprays and this can be exaggerated by subsequent management. However, sward improvement from spraying might be expected if there is an initial establishment of desirable grasses and clovers, and the correct management applied. The better species will develop and replace the eradicated weeds. It appears from the current experiment that, if the best results are to be obtained from the chemical control of weeds, the initial spraying must be followed by adequate manuring. It also appears that the full potential of nitrogen applications may not be realised where weeds are an important constituent of the sward.

Acknowledgments

The authors are grateful to the A.R.C. Unit of Experimental Agronomy for applying the spray treatments, to Drayton N.A.A.S. Experimental Husbandry Farm for the loan of cages and to The Grassland Research Institute, in particular L. Jones and J. R. A. Chard, for carrying out the sward sampling and analyses.

References

[1] Lewis, K. H. C., 'The Use of Weedkillers in Relation to Fat Lamb Production', *Proc. 9th N.Z. Weed Control Conf., 1956*, p. 101

[2] Elliott, J. G., Green, J. O., & Evans, T. A., 'The Effects of MCPB and 2,4-D on Established Legumes', *Proc. Brit. Weed Control Conf., 1956*, p. 477

Discussion on the three preceding papers

Dr. R. E. Slade.—During the war I had a pasture infested with creeping buttercups which would not fatten cattle; also the dried grass was not eaten. I had the opportunity of using some of the first supplies of MCPA and effectively controlled the creeping buttercup. From that time the cattle grazing this field fattened satisfactorily, and also ate the dried grass. This field now has regrown creeping buttercup, and I understand from the owner that it does not fatten satisfactorily.

Dr. H. K. Baker (Grassland Research Inst.).—I have observed that 18 months after spraying with MCPA which controlled the creeping buttercup satisfactorily, a field was being reinfested by freshly germinating buttercup seedlings.

Dr. G. S. Hartley (Fisons Pest Control Ltd.).—I am very pleased to see that, in two of the three papers concerned, the grazing animal is beginning to play a part and I hope that by the time of the next Weed Control Conference it will have proved possible to obtain some evidence of the direct advantage to the farmer of control of weeds in permanent pasture in terms of yields of milk and meat.

It is generally considered that in eliminating weeds out of old permanent pasture the valuable clovers must be preserved, but I notice that the percentage of clover in the analysis given is very small in both cases. Are the speakers of the opinion that these percentages are typical and that, if so, their preservation is of great importance?

Mr. R. S. L. Jeater.—I agree the pastures given in the paper are low in clover content, but with improved management the clover can be brought to a satisfactory level.

Mr. P. A. Oram (Borax Consolidated Ltd.).—Several of the speakers have stressed the effects of herbicides on the clover in the sward, and it is my belief that fear of killing out clover has been the main deterrent to the more extensive use of selective herbicides in grassland by British farmers. However, it has been shown that the percentage of clover in old weedy swards is often low, and one may ask what its value is. It can only have a limited value for maintenance of fertility, since experiments elsewhere have shown that higher production can often be obtained from pure grass stands, with nitrogen supplied from the bag. We have less information, however, concerning its importance to the nutritive value of the pasture and to the needs of the grazing animal. If its effect on production of the various classes of livestock could be determined, the problem of whether its removal by herbicides mattered or not would largely be resolved. Can any of the speakers throw any light on this?

Dr. Baker.—The clover content, though appearing small, amounted to 10–14% dry weight; on the other hand, buttercups and dandelions, although appearing to be present in large quantities because of their erect habit, constituted only 15%.

Dr. William Davies (Grassland Research Inst.).—I suggest to Miss Phillips that she should not exert an undue proportion of her research abilities on comparisons of palatability of grassland plants. There are many more important, if not more interesting, subjects to which our research thoughts should be applied, and very large dividends await him whoever applies his mind to them. It would be dangerous for me to attempt a list of them at this time, but we at Hurley would be glad to discuss all this with you and place our ideas before you; for the more brains we can draw into the grassland agronomy work the better, and I for one would like it.

Further, many of the techniques that we use for measuring grassland outputs are open to serious criticism. I believe that the research worker in grassland in every country of the world has got to do a lot of rethinking about experimental techniques, especially when he or she extrapolates the data derived from these rather crude techniques, and makes conclusions about herbage production, and more important still the output of animal products, which after all is the main object of the grassland work.

2,4-DB AND MCPB IN LUCERNE. I.—Effect of 2,4-DB and MCPB on the development of the lucerne plant

by

R. W. E. BALL and MARGERY SOUNDY

(*Agricultural & Horticultural Research Station, May & Baker Ltd., Ongar*)

Greenhouse and laboratory experiments are described comparing the tolerance of lucerne (var. Provence) towards MCPA, MCPB and 2,4-DB. The dose/mortality and dose/dry weight reduction relationships are used as measurements of crop tolerance and effects are studied at each of four growth stages. Observations are made on stem and leaf distortion. The following main indications have served as a basis for field experiments on six lucerne varieties: (1) that 2,4-DB is approximately three times less toxic than MCPB towards lucerne; (2) that the tolerance of this variety towards 2,4-DB appears to increase up to the 1st–2nd trifoliate leaf stage.

Introduction

Lucerne is known to be less tolerant of growth regulator herbicides than either red or white clovers and its importance as a crop in Europe and the American continent underlines the necessity of finding a weedkiller which it will tolerate. The work leading to the introduction of MCPB as a weedkiller in clover crops suggested that 2,4-DB might offer some advantage over MCPB in lucerne tolerance and the greenhouse experiments here described were designed to compare the two compounds for toxicity to lucerne and to provide information for later field experiments.

Experimental

Plant material

Lucerne seeds (var. Provence) were sown in $3\frac{1}{2}$-in. pots and thinned after germination to five plants per pot. Twelve replicate pots (60 plants) were allocated to each treatment. Experiments were carried out on plants at each of the following growth stages: cotyledon, primary leaf, 1st trifoliate leaf, 2nd trifoliate leaf.

Formulation

MCPA, MCPB and 2,4-DB were each formulated as 40% w/v (active acid equivalent) concentrates of their sodium salts. Amine salts of MCPA, 2,4-DB and 2,4-D were formulated as 20% w/v (active acid equivalent).

Rates of application

Compounds were applied by means of the laboratory sprayer tower[1] as 15-gal./acre sprays at six rates of application.

The following is a summary of the dose rates employed.

Compound	Cotyledon	Primary	1st trifoliate	2nd trifoliate
	Dose rates, lb./acre			
MCPA	0·2–0·8	0·3–1·0	0·4–1·5	0·5–1·8
MCPB	0·6–3·0	0·8–4·0	1·0–4·0	1·5–6·0
2,4-DB	0·8–4·0	1·0–5·0	1·6–6·0	2·0–7·0

After treatment, plants were arranged in the greenhouse in four randomised blocks and kept under optimal growing conditions for a period of five weeks. Counts were then made of surviving plants and percentage mortality for each treatment calculated. This was followed by dry weight estimation for each treatment, the results being expressed as percentage dry weight reduction on controls. Results were plotted on log/probit scales, and from the resulting figures comparison drawn between the ED_{50} and LD_{10} values for each compound.

As experiments of this type are primarily designed to select compounds for field experiments and to choose suitable dose ranges, criteria of crop damage have to be used which approximate to the maximum degree of damage that can be tolerated in field experiments. In the following tables 10% kill of seedlings (LD_{10}) and 50% reduction in dry weight after 5 weeks (ED_{50}) have been used as representing a realistic standard. Recovery of these leguminous forage crops from initial check is known from experience to be more rapid in the field than under greenhouse conditions.

Results

The results are shown in Tables I–VI.

Table I

Dose rates (lb./acre) giving 50% dry weight reduction (ED_{50}) after 5 weeks

Growth stage	MCPA	MCPB	2,4-DB
Cotyledon	0·03	0·26	0·50
Primary	0·05	0·15	0·50
1st trifoliate	0·17	0·60	2·00
2nd trifoliate	0·10	0·40	1·60

Table II

Dose rates (lb./acre) giving 10% kill (LD_{10})

Growth stage	MCPA	MCPB	2,4-DB
Cotyledon	0·07	0·34	1·30
Primary	0·17	0·80	3·40
1st trifoliate	0·40	1·20	3·80
2nd trifoliate	0·25	0·75	4·00

Table III

Dose rates (lb./acre) giving 50% dry weight reduction (ED_{50}) after 5 weeks

Growth stage at spraying	MCPA Na salt	MCPA Amine salt	2,4-DB Na salt	2,4-DB Amine salt	2,4-D Amine
Cotyledon	0·02	0·02	0·40	0·50	0·02
Primary leaf	0·05	0·05	0·66	0·50	0·04
2nd trifoliate	0·24	0·19	2·10	1·30	0·14

Table IV

Activity ratios based on ED_{50}

Growth stage	MCPA/ MCPB	MCPA/ 2,4-DB	MCPB/ 2,4-DB
Cotyledon	9 : 1	17 : 1	2 : 1
Primary	3 : 1	10 : 1	3 : 1
1st trifoliate	4 : 1	12 : 1	3 : 1
2nd trifoliate	4 : 1	16 : 1	4 : 1

Table V

Activity ratios based on ED_{50}

Growth stage	MCPA/2,4-DB Na	MCPA/2,4-DB Amine	2,4-D/2,4-DB Amine
Cotyledon	20 : 1	25 : 1	25 : 1
Primary	13 : 1	10 : 1	12 : 1
2nd trifoliate	9 : 1	7 : 1	9 : 1

Discussion

A comparison of plant reaction at different stages of growth should ideally be treated as one experiment so that environmental differences during the period of recovery are reduced to a minimum. In this work we were compelled by circumstances to treat each growth stage as an individual experiment. In the first series, the four experiments were sprayed during a period of one month and differences in light intensity and duration were almost zero. The second series, concerned with an additional comparison between sodium and amine salt

Table VI

Distorted leaves per treatment at two stages of distortion

Dose rate, lb./acre	2,4-DB Claw leaf	2,4-DB Vestigial leaf	MCPA Claw leaf	MCPA Vestigial leaf	2,4-D Claw leaf	2,4-D Vestigial leaf
0·08	—	—	2	24	6	22
0·15	—	—	8	74	4	42
0·20	—	—	11	69	5	69
0·30	—	—	4	66	4	43
0·50	66	0	2	31	3	58
0·80	58	1	1	18	1	22
1·20	26	13	—	—	—	—
2·00	8	24	—	—	—	—
3·00	12	32	—	—	—	—
4·00	6	39	—	—	—	—

formulations, was spread over a period of four months. Throughout each series a five-week period of recovery was allowed between treatment and dry weight estimations and conclusions relating to susceptibility and growth stage are more valid in series 1.

The results obtained for both mortality and dry weight reduction show that the tolerance of lucerne (var. Provence) towards MCPA reaches a maximum at the 1st trifoliate leaf stage. Results for MCPB and 2,4-DB follow a similar pattern at a higher tolerance level. It is clear from Table IV that in terms of reduction in dry weight 2,4-DB is at least 2–3 times less toxic than MCPB when sprayed at any growth stage up to the 2nd trifoliate leaf. In terms of kill the differences are greater and approach nearer to a factor of five.

For reasons already stated the second series of experiments should be considered solely as a comparison between the sodium and amine salts at each growth stage. It will be noticed in Table III that results for Na and amine salts of MCPA are exactly similar at the cotyledon and primary leaf stages. With 2,4-DB there are indications that the amine salt is more toxic at the primary and 2nd trifoliate leaf stages.

Distortion (Table VI)

Each of the treatments concerned in these experiments produced typical growth-regulator stem distortion within two days of spraying, but the 2,4-DB treatments gave less severe effects than the others. Strong leaf distortion was observed in plants treated at the 1st trifoliate leaf stage and the symptoms did not become apparent until the plants had developed 5–6 trifoliate leaves. Symptoms were typified by a narrowing and thickening of individual leaf blades, so that each trifoliate had a claw-like appearance. It was noted that the affected leaves were not those receiving the spray, or their immediate successors. In general, distorted leaves were found in the 4th–6th trifoliate positions. Counts of the number of distorted leaves per treatment seemed to indicate that 'claw-leaf' distortion occurred mostly in 2,4-DB treatments and that the incidence of distortion decreased with increasing dose rate. Closer examination of all treated plants, however, revealed that (*a*) the higher dose rates of 2,4-DB had produced a more advanced stage of leaf distortion in the 4th–6th trifoliate positions, (*b*) that these leaves were reduced to a vestigial form which was missed in the first count, and (*c*) that nearly all the affected leaves in the 2,4-D and MCPA treatments were vestigial. These results indicate that 'claw-leaf' distortion appears on leaves that were in a rudimentary stage at time of treatment. Subsequent leaves were free of distortion. In the field, the casual observer viewing the crop during the time when 'claw leaves' are in evidence might easily believe the damage to be more severe than that obtained with MCPB. In an experiment on established lucerne, plots sprayed with MCPB and 2,4-DB were scored by eye for 'claw-leaf' damage and for check to growth, and the results are shown in Fig. 1. Each point on the graphs is the mean score for six replicates.

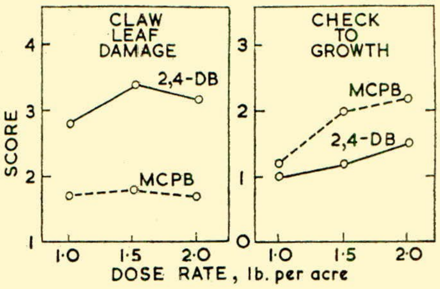
The results show that, although 'claw-leaf' damage was more severe with 2,4-DB than with MCPB, the check to growth was greater with the latter than with the former. The score for growth check was in very good agreement with the final yields at harvest, which are reported in Part III (Experiment 2) below.

Other field observations on 2,4-DB distortion have shown that

(1) stem distortion within 3–4 days of spraying seedling lucerne is slight and effects are

FIG. 1.—*Effect of MCPB and 2,4-DB on established lucerne (three weeks after spraying)*

Score: 0 = no effect 1 = slight effect 2 = moderate effect 3 = severe effect 4 = very severe effect



only noticeable at rates equivalent to 2 and 3 lb./acre on plants at the 2nd–4th trifoliate leaf stage;

(2) claw-leaf distortion appears at a later stage after spraying and the extent of damage depends on the number of leaf buds present at the time of spraying, so that the established plant will produce more claw-leaves than one sprayed in the seedling stage.

Reference

[1] Carpenter, K., Soundy, M., & Wilson, C. W., *Proc. Brit. Weed Control Conf., 1954*, p. 363

2,4-DB AND MCPB IN LUCERNE. II.—The use of 2,4-DB in the establishment of lucerne leys

by

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The results are reported of four experiments with seedling lucerne in which the sodium salt and the butyl ester of 2,4-DB and the sodium salt of MCPA were applied at several growth stages to both pure stands and grass–lucerne mixtures, in both direct and under-sown crops.

Both formulations of 2,4-DB may be safely applied to seedling lucerne at any time between the spade and 4th trifoliate leaf stage. No differences in varietal response were noted between the six lucerne strains used in these experiments.

Significant increases in yield were obtained from applications of up to 48 oz. of the sodium salt of 2,4-DB and of up to 32 oz. of the butyl ester of 2,4-DB, and these increases follow closely the degree of weed control obtained.

Introduction

With the introduction of MCPB in 1954, a safe selective herbicide for use in the early stages of the establishment of both red and white clovers has been available to farmers. This herbicide, however, has been found to be too injurious to young lucerne, but greenhouse experiments have shown that the butyric homologue of 2,4-D is far less phytotoxic. Field experiments, under as wide a range of conditions as possible, were therefore undertaken in 1957 to evaluate the potentialities of 2,4-DB as a herbicide in seedling lucerne. Unfortunately, circumstances were such that the experiments had to be carried out within a few miles of our Research Station at Ongar, so that the range of soil conditions and weed populations was very much restricted.

The main emphasis was on the effects of treatment on direct sown lucerne, because it was easier to obtain immediate yields and consequently to follow the recovery of the lucerne during the succeeding year. Comparison of treatments on both direct and undersown crops was, however, made in two of the experiments.

MCPA was included, because at low dose rates a good control of certain annual weeds such as charlock (*Sinapis arvensis*) and fat hen (*Chenopodium album*) can be obtained, and tentative recommendations for its use are given in undersown crops in some countries, for instance, Canada.

Experimental

Materials and rates

2,4-DB Na salt at 16, 24, 32 and 48 oz. acid equiv./acre; 2,4-DB butyl ester at 12, 16, 24 and 32 oz. acid equiv./acre; MCPA Na salt at 2, 4, 8 and 16 oz. acid equiv./acre. Either three or four unsprayed controls were included in each experiment.

Application methods

All materials were applied through our motorised plot sprayer at 15 gal./acre.[1] Plot size varied from 7×3 ft. to 7×8 ft., and all were arranged in randomised blocks with four replications (Experiments 111B and 111C) and six replications (Experiments 111A/1 and -A/2).

Details of the four experiments

These are given in Table I. All lucerne seed was inoculated immediately prior to sowing, in April 1957.

Table I

Details of experiments

Expt. No.	Location	Lucerne varieties sown as pure stands	Number of lucerne–grass mixtures sown	Growth stages at spraying	Whether direct-sown, undersown, or both
111A/1	Paslow Hall Farm	Provence	2	(1) 2nd–3rd trifoliate (2) 3rd–4th trifoliate	Both Nurse crop—Spring oats, var. Sun II
111A/2	Fyfield Hall Farm	Grimm	2	(1) 1st–3rd trifoliate (2) 3rd–4th trifoliate	Both Nurse crop—Spring wheat, var. Koga II
111B	Ag./Hort. Research Station, Ongar	Grimm Rhizoma Vernal Provence Chartrainvilliers Socheville	6	1st–3rd trifoliate	Direct-sown only
111C	Ag./Hort. Research Station, Ongar	Grimm Socheville		(1) Spade leaf (2) 1st–2nd trifoliate (3) 4th trifoliate	Direct-sown only

Methods of assessment

Fresh weights of lucerne, weeds and grasses were recorded from the direct-sown plots in August 1957, and from both direct and undersown plots in all experiments at the first cut taken in June 1958.

Results

Weed control

In Experiments 111A/2 and 111B there were very mixed weed populations, the most important species being black bindweed (*Polygonum convolvulus*), creeping thistle (*Cirsium arvense*), orache (*Atriplex patula*), fat hen (*Chenopodium album*) and perennial sow thistle (*Sonchus arvensis*). In Experiment 111A/1 a mixed weed population was very rapidly dominated by one weed, knotgrass (*Polygonum aviculare*), and by harvest time this was practically the only weed present in any plot. The site of Experiment 111C was very clean and only occasional plants of fat hen, creeping thistle and perennial sow thistle occurred.

Weed counts were taken 6 weeks after spraying, the results of which are shown in Table II. In the case of Experiment 111A/1 the results on knotgrass are given as percentages of the weights at harvest, as this was virtually the only weed present.

Table II

Control of major weed species in each experiment

(figures as % control of plant numbers: knotgrass % by wt., herbicide dosage oz./acre)

	Black bindweed (*Polygonum convolvulus*)	Creeping thistle (*Cirsium arvense*)	Orache (*Atriplex patula*)	Fat hen (*Chenopodium album*)			Perennial sow thistle (*Sonchus arvensis*)		Knotgrass (*Polygonum aviculare*)	
Average height at spraying, in.	1–1½	4–8	1–2	1–2	1*	3†	2–3*	4–6†	6–10*	9–12†
Expt. No.	111B	111B	111B	111B	111A/2	111A/2	111A/2	111A/2	111A/1	111A/1
2,4-DB Na salt										
16	56	66	40	98	80	88	52	53	69	9
24	76	85	30	93	89	97	—	79	53	22
32	73	45	55	98	87	94	43	64	82	21
48	84	64	75	100	88	94	65	52	85	47
2,4-DB ester										
12	45	65	78	98	73	95	71	96	82	77
16	64	52	76	93	89	97	90	96	90	86
24	67	91	83	95	94	98	95	90	96	95
32	67	58	81	97	90	100	87	100	94	95
MCPA Na salt										
2	18	20	21	83	46	42	—	—	5	—
4	26	29	47	65	—	59	4	—	12	—
8	3	35	55	93	50	42	—	16	—	—
16	19	78	37	88	80	77	17	—	—	15
Control population per sq. yd. at time of assessment	35 × 15 in.	10 × 12 in.	29 × 8 in.	7 × 14 in.	5 × 29 in.		2 × 26 in.		47 cwt./acre	

* 1st spray † 2nd spray

The best, and most consistent, weed control was obtained with the ester, which gave excellent kills of fat hen, knotgrass, orache and perennial sow thistle. Control of black bindweed was fair to good, and the control of creeping thistle was generally rather erratic. The sodium salt was only a little inferior to the ester in most cases, but larger dose rates were needed and timing was very much more important. This was particularly the case with knotgrass, which was well controlled by the first spraying in Experiment 111A/1 but which became almost resistant by the time of the second spray. The low rates of MCPA were only sufficient to give a good control of fat hen (at 8 and 16 oz.), and a fair control of orache. The *Polygonum* species were almost completely resistant to 16 oz. of MCPA per acre.

Effect on lucerne yield

(1) *Interaction with weed control.*—The harvest weights of lucerne in the three experiments in which both weed and lucerne fresh weights were recorded are shown in Figs. 1–4, and they demonstrate very clearly that the final crop yield was very closely associated with the degree of weed control obtained with each treatment. All the 1957 yield increases with the 2,4-DB treatments were statistically significant at the 5% point, and many at the 1% point.

(2) *The earliest safe growth stage for treatment.*—Fig. 4 gives details of the harvest weights of lucerne sprayed at three growth stages, the results of which indicate that, in the case of the two 2,4-DB formulations, treatment can be applied with safety at any time from the spade to the 4th trifoliate leaf stage.

(3) *Varietal reaction to treatment.*—Direct comparison of representative Canadian and French varieties is given in Table III. Individual results are rather variable, but the figures

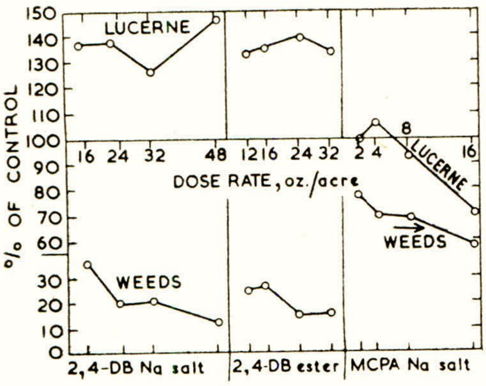

FIG. 1.—*Fresh weights of lucerne and weeds as % of control* (Experiment 111B)

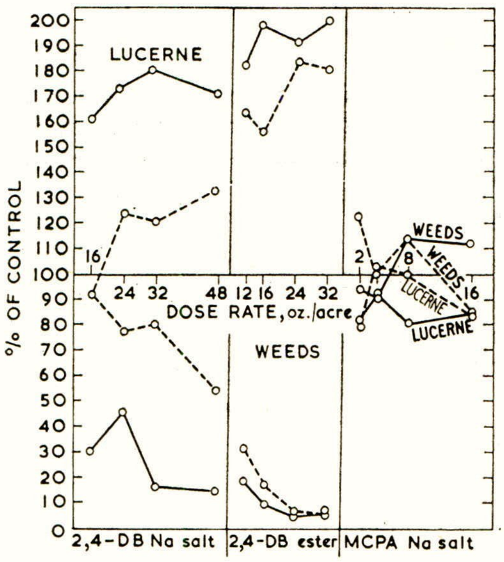

FIG. 2.—*Fresh weights of lucerne and weeds as % of control* (Experiment 111A/1)

——— sprayed at 2–3 trifoliate; - - - - - - - at 3–4 trifoliate

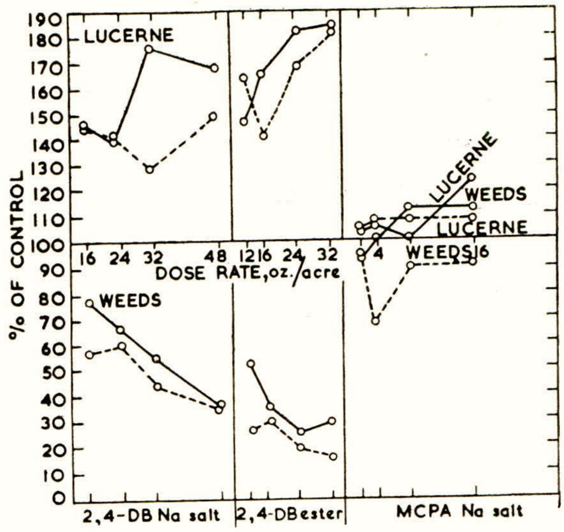

FIG. 3.—*Fresh weights of lucerne and weeds as % of control* (Experiment 111A/2)

——— sprayed at 1–2 trifoliate; - - - - - - - at 3–4 trifoliate

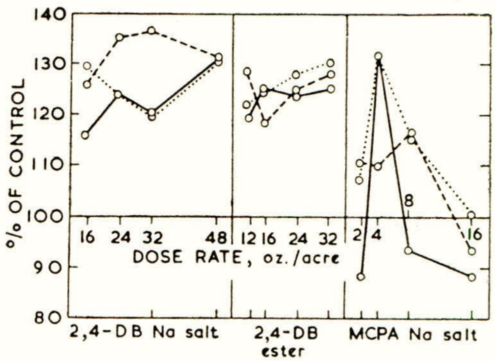

FIG. 4.—*Comparison of treatments at different growth stages* (Experiment 111C)
Fresh weights of lucerne as % of control
(mean of 2 varieties)

——— sprayed at spade leaf; - - - - - - - at 1–2 trifoliate
· · · · · · · · at 3–4 trifoliate

indicate that no one variety appears to be more susceptible to treatment. The analysis of variance supports this, the variance for the interaction of treatments and varieties being much less than the error variance, and in fact being the smallest variance in the table.

(4) *Effect of treatments on undersown crops.* No yield assessments on undersown lucerne could be made during the year of sowing, but comparison with the direct-sown crops was made at the first harvest cut in the following year. This is shown in Table IV, which also includes the harvest results, for 1957, of the direct-sown lucerne. With few exceptions, the results on the undersown crop follow closely those of the comparable 1958 figures for the direct-sown.

(5) *The effect of competition by companion grasses.*—Although lucerne grass mixtures were included in each experiment, it was only possible to analyse in detail, in 1957, the proportions of grass to lucerne in Experiment 111B (Table V). The results show that the only treatments to have significantly altered the percentage of grass are the two highest rates of MCPA. A similar assessment of the first harvest cut in 1958 shows that, with few exceptions, the proportion of grass to lucerne in the 2,4-DB plots is similar to that in the controls. The percentage of grass in all the MCPA plots remains higher than in the controls, and these increases are substantial at the higher dose rates.

Table III

Varietal response to treatment (Experiment 111B)
(Fresh weights as % of control)

Material	Applied rate, oz./acre	Grimm	Rhizoma	Vernal	Provence	Chartrain-villiers	Socheville
2,4-DB Na salt	16	125	142	148	135	133	147
	24	147	148	147	132	130	153
	32	118	145	131	130	120	151
	48	168	170	148	150	137	152
2,4-DB ester	12	143	149	132	138	95	142
	16	139	152	121	135	137	139
	24	130	171	132	132	138	159
	32	126	149	133	146	121	133
MCPA Na salt	2	107	97	113	102	101	102
	4	107	111	104	117	102	102
	8	94	96	97	98	100	101
	16	83	80	72	66	62	73
Control yield, cwt./acre	—	90	85	96	80	78	83

Comparison of treatments in both direct and undersown lucerne/cocksfoot mixtures is shown by the analysis of the first cut in Experiment 111A/1 (Table VI). Substantial increases in both lucerne and grass weights are still evident in the 2,4-DB treatments in the direct-sown plots, whereas any increases in the first year have evened out in the undersown plots.

Table IV

Effect of cover crop on reaction to treatments
(fresh weights as % of control)

Material	Dosage, oz./acre	Experiment 111A/1 Cover crop—oats Direct-sown 1957	Direct-sown 1958	Undersown 1958	Experiment 111A/2 Cover crop—wheat Direct-sown 1957	Direct-sown 1958	Undersown 1958
2,4-DB Na salt	16	161	105	87	143	106	98
	24	174	98	93	140	106	101
	32	182	102	109	128	97	101
	48	170	95	93	149	113	109
2,4-DB ester	12	182	111	93	164	98	103
	16	198	113	102	139	97	111
	24	191	111	97	166	116	95
	32	200	130	107	179	106	106
MCPA Na salt	4	90	87	82	105	97	116
	8	82	67	76	105	101	121
Major weeds			knotgrass			fat hen perennial sow thistle	

Discussion

The large increases in yield obtained in these experiments show that weed competition in the early seedling stages of a direct-sown lucerne ley can exert a considerable adverse effect on the plants, and that early removal of this weed competition can result in substantial increases in harvest yields during the year of seeding. In the three experiments where both weed and lucerne weights were recorded there were sufficient control plots present to obtain a wide range of both weed and lucerne weights. Statistical analysis showed that the linear regressions of lucerne on weeds were highly significant in the experiments containing mixed weed populations, but not in Experiment 111A/1 where knotgrass rapidly became the dominant species. The regression equations, both significant at the 0·1% level, of the other two experiments were as follows:

111A/2 Lucerne yield (per plot) $= 1752$ g. $-0{\cdot}96 \times$ weeds (g.)
111B Lucerne yield (per plot) $= 1509$ g. $-0{\cdot}47 \times$ weeds (g.)

Table V

Effect of treatments on the composition of sward (direct-sown lucerne) (Experiment 111B)
(% by wt. of grasses in sward (excluding weeds))

Lucerne		Grimm		Chartrainvilliers		Grimm		Chartrainvilliers		Grimm		Chartrainvilliers	
Grasses		Cocksfoot S.37		Cocksfoot S.37		Timothy S.51 Meadow fescue S.215		Timothy S.51 Meadow fescue S.215		Brome (*Bromus inermis*)		Timothy S.51	
Material	oz./acre	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958
2,4-DB Na salt	16	13·1	58	20·3	65	7·1	37	10·8	52	6·2	29	5·1	43
	24	13·9	61	19·5	65	7·5	41	14·5	60	11·1	44	9·6	38
	32	17·6	59	17·5	69	11·3	38	15·7	58	5·4	38	9·5	40
	48	7·4	49	20·3	70	6·1	43	8·3	46	3·6	32	3·7	35
2,4-DB ester	12	11·9	57	19·5	70	12·5	43	10·6	52	3·6	41	6·5	38
	16	9·4	55	17·9	83	6·7	41	9·1	52	4·6	32	5·9	35
	24	10·8	49	21·0	67	10·7	42	15·5	58	6·9	39	6·5	36
	32	10·0	52	21·4	67	7·8	36	13·5	48	5·5	37	5·5	40
MCPA Na salt	2	24·8	65	31·1	61	10·6	44	17·6	54	5·7	41	9·1	38
	4	20·0	62	22·8	65	10·6	49	16·5	61	9·5	31	8·0	40
	8	33·2	67	38·3	76	18·5	56	23·6	63	14·8	50	16·4	53
	16	29·2	75	51·7	86	32·4	66	34·5	66	23·6	59	23·9	55
Control	—	20·4	60	17·9	63	6·9	39	11·1	48	4·6	31	5·0	34

Table VI

Comparison of effects of treatments on composition of sward in direct and undersown crops (Experiment 111A/1)
(fresh weights (cwt./acre) of lucerne and grass harvested in June 1958)

Material	Dosage, oz./acre	Direct-sown Lucerne	Direct-sown Cocksfoot	Undersown Lucerne	Undersown Cocksfoot
2,4-DB Na salt	16	30·9	167	16·5	100
	24	28·6	167	15·3	107
	32	29·5	164	19·2	100
	48	31·2	153	14·2	104
2,4-DB ester	12	29·6	166	13·3	107
	16	28·8	144	14·8	120
	24	31·4	146	11·5	118
	32	36·0	172	14·0	127
MCPA Na salt	4	17·1	146	8·1	92
	8	14·2	151	8·7	107
Control	—	23·1	144	14·7	101

These equations pre-suppose that the relationship between the weeds and lucerne is truly linear, and although this is not the case over the whole range, it is nearly correct over the centre of the range.

The more severe effect of the weeds in Experiment 111A/2 is probably due to the poorer soil conditions at the time of sowing and the generally poorer growing conditions in this experiment.

The first-year yield increases in the majority of the experiments have evened out by the first cut in the following year, with the exception of Experiment 111A/1 (Table IV). Here increases over the control of up to 130% are still being obtained, probably because the smothering effect of the dominant knotgrass resulted in very large increases in the seedling year.

It is worthy of note that even in Experiment 111C, which appeared to be almost weed-free, yield increases over the controls were obtained in the first year. Similar effects in very lightly infested crops have been reported by Evans.[2]

All the experiments discussed in this report were spring sown and consequently had a long growing season in which to overcome the effects of spraying. In observations on plots sown in July and sprayed in August it was noticed that this recovery may be hampered by adverse weather conditions during the autumn. If weeds resistant to 2,4-DB, and in particular speedwell (*Veronica* spp.) and chickweed (*Stellaria media*), are present, these may grow away and completely smother the crop.

It is often recommended that weeds in stands of direct-sown seedling lucerne should be controlled by the use of the mower, with the cutter bar set as high as possible to avoid damage to the crowns of the lucerne plants. Very good results have been obtained with this method, particularly where the main weeds are of an erect habit. Where, however, a proportion of the weeds are of the prostrate smothering type (e.g. knotgrass, orache), this may not be sufficient and 2,4-DB offers a safe method of control. The use of a herbicide also means that a cut can be delayed until much later, giving a higher harvest yield and a better chance for the young lucerne plants to get well established. In undersown crops topping is not possible, and in weedy situations 2,4-DB offers an effective solution.

References

[1] Carpenter, K., Soundy, M., & Wilson, C. W., *Proc. Brit. Weed Control Conf., 1954*, p. 363

[2] Evans, S. A., *Exp. Husbandry*, 1957, **2**, 67

2,4-DB AND MCPB IN LUCERNE. III.—THE EFFECTS OF MCPB AND 2,4-DB ON ESTABLISHED LUCERNE

by

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Two experiments, in comparatively weed-free, one-year-old lucerne stands, are reported, in which the sodium salts of 2,4-DB and MCPB and the butyl ester of 2,4-DB were compared. 2,4-DB was found to be less phytotoxic to lucerne than MCPB and the sodium salt of 2,4-DB gave higher yields than the butyl ester. There are indications that recovery of the lucerne is slower in the presence of vigorous grass growth. There were no differences in varietal reaction to treatment.

Introduction

During 1957 2,4-DB was evaluated as a herbicide in seedling lucerne, the results of which are reported in Part II (preceding paper). As a result of these experiments 2,4-DB was made available to farmers in Britain early in 1958, and since then many requests for information on its suitability in established crops have been received. Little published information of work in this country is available, although one experiment[1] was reported in the proceedings of the last Weed Control Conference.

Two experiments were therefore laid out in 1958, both in one-year-old stands, to determine the effect of applying 2,4-DB and MCPB at different stages of growth of lucerne. MCPB was included because a number of reports, particularly from overseas, have suggested that this material is reasonably well tolerated by established lucerne. In neither of the experiments were broad-leaved or grassy weeds a problem, the main purpose of the experiments being to determine the toxicity of the materials to the crop in the field.

Experimental

Both experiments were direct-sown in April 1957 and received one cut in August that year, the aftermath being allowed to die down naturally in the autumn. In Expt. 1 silage cuts were taken during late May and early July, treatments being applied 6 and 19 days after the second cut. In Expt. 2 a late hay cut was taken at the end of June, and the treatments were applied 12 days afterwards.

Six pure stands of lucerne (Grimm, Vernal, Rhizoma, Socheville, Chartrainvilliers and Provence) were used in Expt. 1, and one pure stand (Grimm) and two lucerne–grass mixtures in Expt. 2. The grass mixtures were (A) Grimm–brome grass (*Bromus inermis*), and (B) Grimm, brome grass, timothy S.51, cocksfoot S.37 and ladino clover.

The materials used were the sodium salt of 2,4-DB at 16, 24 and 32 oz., the butyl ester of 2,4-DB at 12, 16 and 24 oz. and the sodium salt of MCPB at 16, 24 and 32 oz. acid equiv./acre. Application was at 15 gal./acre, using our experimental small plot sprayer. The plot size was 7×3 ft. in Expt. 1, and 7×8 ft. in Expt. 2. Two controls were included in each randomised block (4 replications) in Expt. 1, and four in each randomised block (6 replications) in Expt. 2.

Assessments

Fresh weights of an area of 4 ft.×6 rows were taken from each plot. In Expt. 2 the herbage was separated into lucerne, weeds and grass fractions and the individual weight of each fraction recorded.

Results

The lucerne fresh weights are given in Table I. The six varieties in Expt. 1 were recorded separately (Table II), but as the analysis of variance showed that there were no differences in varietal reaction to any of the chemicals, the means for the six varieties are combined in Table I.

Table I

Reaction of lucerne to treatments

(values are fresh wt. as % of control; treatments, oz. acid equiv./acre)

	Pure lucerne (mean of 6 varieties)		Mean of 3 mixtures	Pure lucerne	Lucerne in mixture A	Lucerne in mixture B
	Experiment 1			Experiment 2		
Height of re-growth at time of spraying, in.	2–4	8–13	3–4	3–4	3–4	3–4
Interval between previous cut and harvest, days	55	55	50	47	49	55
Interval between spraying and harvest, days	49	36	38	35	37	43
Treatments						
2,4-DB Na salt						
16	98	93*	90*	90	85	93
24	100	86**	87**	89	75	94
32	95	85**	78**	84	68	80
2,4-DB ester						
12	91**	94*	83**	90	72	84
16	99	83**	80**	95	65	75
24	94*	77**	76**	80	69	78
MCPB Na salt						
16	94*	81**	89**	93	78	93
24	94*	69**	74**	75	67	79
32	85**	61**	66**	67	66	67

* Significantly different from the controls at the 5% point.
** ,, ,, ,, ,, ,, ,, ,, 1% ,,

The harvest in Expt. 2 was not completed until the end of August, with the result that it has only been possible so far to analyse in detail the figures of the lucerne fraction of the grass–lucerne mixtures. The individual plot variation in this experiment was higher than in Expt. 1, and although the reaction of the lucerne in the three swards appears to show noticeable differences, these are not statistically significant. Figures for the individual mixtures, however, are included in the table, together with the general means for the three mixtures combined.

Discussion

The results of these experiments have confirmed those of other workers that 2,4-DB is less toxic to established lucerne than MCPB, particularly at rates of 24 and 32 oz./acre, which in this country would be essential for a good control of the main broad leaf weeds (creeping thistle, *Cirsium arvense,* and docks, *Rumex* spp.) that occur in established lucerne stands. Of the two

Table II

Reaction of six lucerne varieties to treatment (Experiment 1)
(fresh weights as % of control)

Material	Dosage, oz./acre	Provence	Socheville	Chartrain-villiers	Grimm	Vernal	Rhizoma
1st Spraying							
2,4-DB Na salt	16	91	99	94	97	101	106
	24	89	105	87	111	100	109
	32	90	97	100	98	92	93
2,4-DB ester	12	82	87	87	109	88	102
	16	97	95	98	106	101	105
	24	92	92	91	104	91	101
MCPB Na salt	16	90	97	89	96	95	98
	24	87	91	102	94	97	100
	32	91	82	78	89	82	85
2nd Spraying							
2,4-DB Na salt	16	86	95	88	111	95	89
	24	80	82	87	104	81	87
	32	80	83	83	98	89	84
2,4-DB ester	12	86	93	103	110	85	93
	16	81	86	74	87	87	79
	24	77	78	72	88	76	75
MCPB Na salt	16	79	83	82	86	80	79
	24	70	71	69	70	69	64
	32	55	63	56	68	61	63

2,4-DB formulations, the sodium salt gave consistently higher harvest yields than did comparable rates of ester. At 16 oz./acre MCPB compared favourably with the sodium salt of 2,4-DB, but at 32 oz. the yields with the former were very severely depressed.

With the exception of the three 2,4-DB sodium salt treatments at an early growth stage in Expt. 1, all treatments gave significant reductions over the controls. It must be remembered, however, that in neither of these experiments was the broad-leaf weed population of any magnitude (for most plots the weights of weeds were approximately 1% or less), and in farm conditions the spraying of such crops would not normally be contemplated. A severe infestation of docks and thistles would almost certainly have reduced the control weights.

From the limited amount of data available, it is difficult to assess the relative importance of the height of regrowth at spraying and the interval between spraying and harvest as factors influencing the final weights at harvest. It is obvious, however, that some check to the lucerne is unavoidable, and the earlier the spraying is carried out after a cut, the longer the crop will have in which to recover before its next defoliation. In a vigorous grass sward, such as occurred in Mixture B (Expt. 2), this recovery may be further hampered by the competition from the grasses, or, in pure lucerne stands, from any weed grasses present.

In the field, the plots sprayed early tended to appear worse for about 10 days after spraying than those sprayed later, mainly because the plants in the latter had a greater amount of normal foliage before the treatment effects appeared. At harvest time, however, there was little difference in appearance between the two sprayings.

Reference

[1] Elliott, J. G., Green, J. O., & Evans, T. A., *Proc. 3rd Brit. Weed Control Conf., 1956*, p. 477

2,4-DB AND ITS BUTYL ESTER: RESIDUE LEVELS IN SEEDLING LUCERNE

by

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Results of experiments to determine the persistence under various experimental conditions of γ-(2,4-dichlorophenoxy)butyric acid (2,4-DB) and its butyl ester in field crops of seedling lucerne are reported. Assays, which were specific, were carried out by infra-red spectroscopy of plant extracts prepared by rapid non-quantitative procedures and all losses were corrected for by an isotope dilution technique using compounds labelled with ^{14}C. Results were further corrected for plant growth dilution.

In no case did the residue level of 2,4-DB sprayed as the sodium salt at normal rates up to 3 lb./acre exceed 1 p.p.m. after 28 days, but at the very high rate of 4 lb./acre a level of 1 p.p.m. was not reached until 42 days after spraying.

The butyl ester was rapidly broken down to 2,4-DB inside the plant and the persistence of 2,4-DB in ester-treated plants was longer than in plants treated under the same conditions with 2,4-DB sodium salt.

Introduction

Data on the persistence of herbicides are required for crops grown for human or animal consumption and any method of analysis should preferably be sensitive to at least 1 p.p.m. It is imperative that analytical methods for 2,4-DB and its ester should be specific because the acid, phenol and free halogen content of plants is so high and variable as to interfere with methods based on ultra-violet spectroscopy, polarography, the determination of the corresponding phenols after hydrolysis with HBr or the determination of chlorine after reduction of the compounds with sodium or with Raney nickel. Infra-red spectroscopy is the only specific method discovered to date and the greatest sensitivity is obtained using the KBr pressed disc technique.[1]

As the use of organic solvents proved unreliable for the extraction of these and other organic compounds from plant material, 2,4-DB was extracted with an aqueous solution and the ester recovered by steam distillation.

An isotope dilution technique[2] using ^{14}C-labelled compounds was used to correct for the large and variable losses which occur during the purification of plant extracts for infra-red analysis. Corrections for growth dilution have been applied to all results.

Throughout this work the aims have been to establish curves for the persistence of the various compounds under a variety of conditions and to attempt to determine any relation between persistence and variable factors such as spray rate, weather conditions, or growth stage of the plants at the time of spraying.

Experimental

Field experiments

The formulations used in the experiments were 30% w/v 2,4-DB sodium salt and 40% w/v 2,4-DB butyl ester.

In all experiments the layout consisted of randomised blocks with four replications, the individual plot size being 19×7 ft. The variety of lucerne used was Canadian Grimm, sown in rows 6 in. apart at a seed rate of 16 lb./acre. Seed was inoculated immediately prior to sowing. Spraying was carried out using a motorised small plot sprayer[3] and all treatments were applied at a volume rate of 15 gal./acre, at 37 lb./sq. in. pressure. Three series of experiments were carried out during 1957 and 1958 and details are given in Table I. Spray rates are all expressed in terms of lb./acre 2,4-DB acid equivalent. Samples were cut by hand using shears, the plants being cut off at ground level and immediately placed in polythene bags. The fresh weight of each sample was taken and the length of row per cut noted. Air temperatures were recorded throughout the period of each experiment and in the case of Expts. 2 and 3, details of rainfall were also recorded. In Expt. 1 no measurements of rainfall were possible but a note was taken of the days on which rain fell. Frequent observations on the growth of the plants were made and symptoms of spray damage carefully noted.

Table I

Details of field experiments on the persistence of 2,4-DB and its butyl ester in seedling lucerne

Expt. No.	Date of spraying	Compound	Spray rate, lb./acre 2,4-DB equiv.	Stage of growth at time of spraying	Initial concn. of 2,4-DB or ester, p.p.m.	No. of days after spraying at which concn. < 1 p.p.m.	Days after spraying when normal growth first observed
1a	16th Aug., 1957	2,4-DB Na salt	1½	7–9 trifoliate leaves	140 2,4-DB	21	17
b	,, ,, ,,	,, ,, ,,	2	,, ,, ,,	—	28	21
c	,, ,, ,,	,, ,, ,,	3	,, ,, ,,	—	28	35
d	,, ,, ,,	,, ,, ,,	4	,, ,, ,,	—	42	42
2a	19th May, 1958	2,4-DB Na salt	1½	1–2 trifoliate leaves	365 2,4-DB	11	8
b	,, ,, ,,	,, ,, ,,	3	,, ,, ,,	680 2,4-DB	11	8
c	,, ,, ,,	2,4-DB ester	3/4	,, ,, ,,	—	2	—
		2,4-DB present from breakdown of ester	—	—	—	17	8
d	,, ,, ,,	2,4-DB ester	1½	,, ,, ,,	—	4	—
		2,4-DB present from breakdown of ester	—	—	—	17	11
3a	11th Aug., 1958	2,4-DB Na salt	1½	3–4 trifoliate leaves	203 2,4-DB	7	4
b	,, ,, ,,	2,4-DB ester	1½	,, ,, ,,	287 ester	1	—
		2,4-DB present from breakdown of ester	—	—	—	16	10

Analytical techniques

The analytical techniques, which are described in detail elsewhere,[4] are summarised below:

(*a*) 2,4-*DB*.—The powdered sample (dried overnight at 100°) is extracted with 0·1N-NaOH with addition of a known quantity of ^{14}C-labelled 2,4-DB of known specific activity. The solution obtained on filtration is acidified and proteins etc., precipitated with phosphotungstic acid. Free 2,4-DB is extracted from the filtrate with CCl_4 and isolated by successive re-extractions with sodium bicarbonate solution and *n*-hexane. The hexane solution is evaporated on to KBr and a pressed disc prepared for infra-red analysis. The absorption at 13·5μ is measured and the 2,4-DB content calculated by reference to a standard curve. The specific activity of the 2,4-DB in the disc is measured and the recovery of active compound used to correct the results for unavoidable losses.

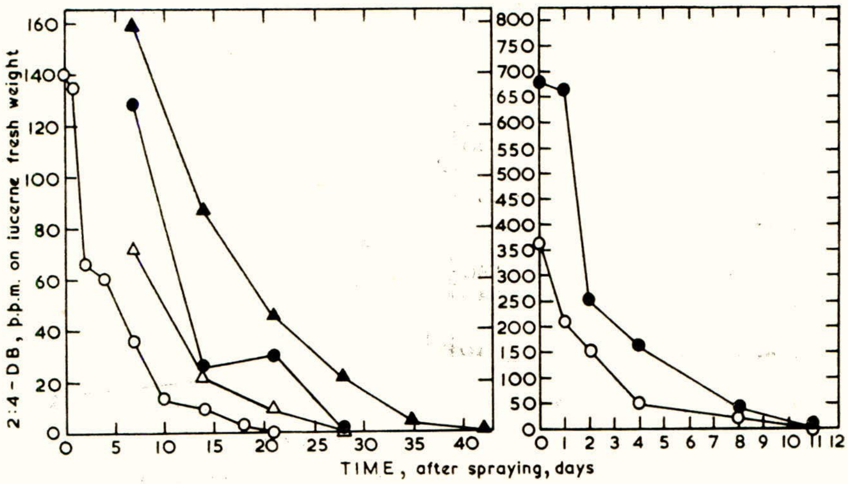
(*b*) *Butyl ester of* 2,4-*DB*.—The sample of fresh plant is macerated with water and the ester separated by steam distillation and hydrolysed with alcoholic sodium hydroxide. After acidification of the solution the free 2,4-DB is extracted with CCl_4, purified by re-extraction as described in (*a*) above, and estimated by infra-red spectroscopy. Corrections for losses occurring during the extraction and isolation procedure are applied to the analytical results by means of the isotope dilution technique using ^{14}C-labelled ester.

Results

Results of the field experiments are presented in the form of curves relating residue levels with time after spraying for each compound and in all cases the residue levels have been corrected for growth dilution, that is, the decrease in concentration caused by the growth of the plants over the experimental period. Details of the experiments are shown in Table I.

2,4-DB

Results obtained in Expt. 1 on the persistence of 2,4-DB sprayed as the sodium salt are shown in Fig. 1. The 2,4-DB concentrations at zero time for the 2, 3 and 4 lb./acre rates are unreliable because of a fault in the infra-red technique which has since been corrected and, therefore, only those starting from the 7th day after spraying are reported for these rates. Results of Expts. 2a, 2b and 3a are shown in Figs. 2 and 3.



Persistence of 2,4-DB (Na salt) in seedling lucerne

Fig. 1
Expt. 1, Aug. 1957

Fig. 2
Expt. 2, May 1958

Spray rates, acid equiv. in lb./acre

Expt. 1a	○——○	1
1b	△——△	2
1c	●——●	3
1d	▲——▲	4
Expt. 2a	○——○	$1\frac{1}{2}$
2b	●——●	3

In these experiments all rates of treatment produced an initial check to the lucerne and at higher rates moderate leaf and stem distortions occurred. The colour of the leaves was generally duller than that of unsprayed lucerne. Only in the case of the high dose rate of 4 lb./acre did slight symptoms of scorch appear. There was considerable variation in the time taken for normal growth to appear, as is indicated in Table I.

Butyl ester of 2,4-DB

Exploratory experiments (2c and 2d) on the persistence of the ester in lucerne showed that it disappeared so rapidly that significant results could only be obtained if estimations were carried out at once on plants which had been cut immediately after drying and subsequently at intervals of hours rather than days. It was suspected that the ester was broken down to 2,4-DB in the plant and, therefore, estimations of the 2,4-DB content were carried out when the ester content had reached the limit of detection. Substantial amounts of 2,4-DB were found.

Another experiment (3b) was therefore started at the same time as one in which the sodium salt was used (3a) in order to compare the persistence of 2,4-DB resulting from the breakdown of the ester with that of 2,4-DB sprayed as the sodium salt.

The results of Expt. 3b are shown in Fig. 4. The concentrations of ester over the period of its persistence and of 2,4-DB from the point at which the ester had disappeared were experimentally determined, and the 2,4-DB concentrations over the period of the breakdown of the ester were then calculated from these results.

The reaction of the lucerne to the ester in all experiments was much more rapid and severe than at corresponding rates of the sodium salt and leaf scorch appeared 12–72 hours after treatment. Recovery from the ester treatment was also much slower than from the sodium salt at comparable spray rates as can be seen in Table I.

Discussion

A detailed analysis of the persistence curves is difficult because a number of variable factors including stage of growth of the plants at the time of spraying, temperature, rainfall, humidity and light intensity were involved in the three experimental periods but some conclusions can be drawn which are of interest to the user of these selective herbicides.

2,4-DB

The initial concentration of 2,4-DB, when sprayed as the sodium salt at a rate of $1\frac{1}{2}$ lb./acre, varied widely in three experiments (Table I). The plants were sprayed at a different growth

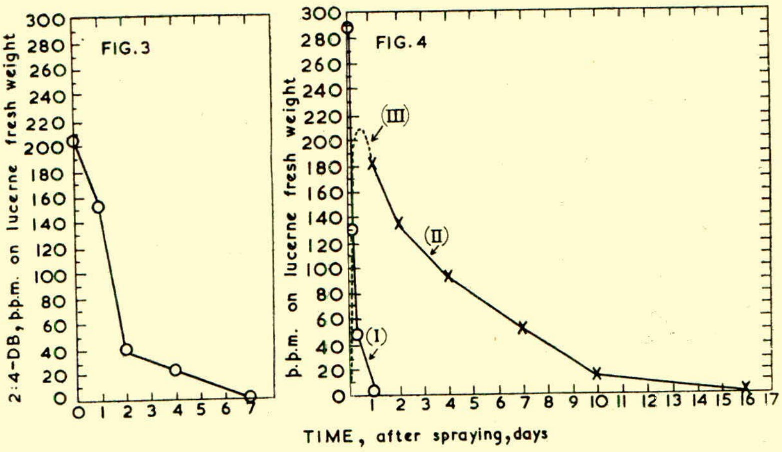


FIG. 3.—*Persistence of 2,4-DB (Na salt) in seedling lucerne*
(Expt. 3a, Aug. 1958; spray rate 1½ lb./acre 2,4-DB equivalent)

FIG. 4.—*Persistence of 2,4-DB ester and of 2,4-DB derived from the ester in seedling lucerne*
(Expt. 3b, Aug. 1958; spray rate 1½ lb./acre 2,4-DB equivalent)

(i) O——O 2,4-DB butyl ester
(ii) X——X 2,4-DB from breakdown of ester
(iii) - - - - - - 2,4-DB ,, ,, ,, ,, calculated from (i) and (ii)

stage in each experiment and the initial concentration was inversely proportional to the size of the plants at the time of spraying.

It is not possible to compare the initial concentrations at different spray rates in Expt. 1 as reliable values at zero time for the 2, 3 and 4 lb./acre rates were not obtained. In Expts. 2a and 2b, however, initial concentration increased with increasing spray rate; at a rate of 3 lb./acre it was approximately double that at 1½ lb./acre.

The persistence of 2,4-DB in seedling lucerne expressed as the number of days after spraying required for the concentration to decrease to the limit of detection of 1 p.p.m. is very variable. Thus, at 1½ lb./acre 2,4-DB has persisted in different experiments for 7, 11 and 21 days and in two experiments at 3 lb./acre for 11 and 28 days. With variation in dose rate, 1½-, 2-, 3- and 4-lb./acre sprays gave persistence times of 21, 28, 28 and 42 days respectively, but in another series of experiments the persistence was 11 days for dose rates of 1½ and 3 lb./acre. An examination of the results of these experiments showed that the persistence of 2,4-DB must be affected by a complex combination of factors and the relative importance of these cannot be stated without obtaining more detailed data from carefully controlled laboratory experiments. It is suggested that rainfall and temperature are important factors because an examination of Fig. 3 shows that between the first and second days, when there was fairly heavy rainfall and high temperatures, a much larger decrease occurred in the 2,4-DB concentration than over the same period of comparable experiments (Figs. 1 and 2) when temperatures were lower and no rainfall occurred. The limit of detection of 2,4-DB was always reached, however, in 28 days or less for normal spray rates of not greater than 3 lb./acre of the sodium salt under a variety of conditions and, in general, the appearance of normal growth in the majority of plants occurred a few days before a concentration of 1 p.p.m. was reached.

2,4-*DB butyl ester*

The main feature of the results for the persistence of the ester is its very rapid breakdown to 2,4-DB in the plant as first indicated in the exploratory experiments and shown in greater detail in Expt. 3b. The initial concentration of ester in this experiment is in reasonable agreement with that of 2,4-DB from the sodium salt sprayed at the same rate (Expt. 3a) when allowance is made for differences in the molecular weights of the two compounds (Table I). The breakdown of ester to 2,4-DB was complete within 24 h. in this case but in Expt. 2d at the same spray rate the persistence was 4 days. Temperature is probably an important factor in the breakdown of the ester as it was significantly higher during Expt. 3b (average max. 68°, min. 44°F) than during Expt. 2d (average max. 73°, min. 54°). The evaluation of the effects of temperature and other variable factors would again require more detailed data from carefully controlled experiments.

A comparison of Figs. 3 and 4 shows that the concentration of 2,4-DB in the plants when the ester had disappeared was of the same order as that of 2,4-DB in plants sprayed at the same rate of sodium salt. The subsequent decrease of 2,4-DB in the ester-treated plants was at a much slower rate than in plants treated with the sodium salt and reached the limit of detection in 16 days for the ester treatment and 7 days for the sodium salt. This longer persistence of 2,4-DB derived from the ester was also shown in other experiments and by a delay in the appearance of normal growth of the plants.

Scorch was observed in all cases where the butyl ester was applied. The symptoms appeared within 12–72 h. of spraying but no further scorch occurred after the limit of detection of the ester had been reached. In Expt. 3b scorch was first observed at roughly the time of the calculated peak concentration of 2,4-DB when the ester concentration had decreased considerably. Scorch was not produced at a similar concentration of 2,4-DB after spraying with the sodium salt but only when the very high rate of 4 lb./acre was applied. It is possible that the scorch symptoms are caused by the presence of 2,4-DB derived from the ester in parts of the plant only penetrated with difficulty by the sodium salt. This difference in penetration might also explain the longer persistence in the plant of 2,4-DB derived from the ester.

Conclusions

1. Satisfactory methods sensitive to 1 p.p.m. have been developed for the estimation of residues of 2,4-DB and its butyl ester in lucerne.

2. In a series of field experiments the persistence of 2,4-DB applied as the sodium salt to seedling lucerne at spray rates up to 3 lb./acre was 7–28 days and dependent upon initial dose rate and growing conditions. When the very high spray rate of 4 lb./acre was used the limit of detection was not reached until 42 days after spraying.

3. In field experiments on the persistence of the butyl ester of 2,4-DB in seedling lucerne the ester was rapidly broken down to 2,4-DB in the plant.

4. The persistence of 2,4-DB in ester-treated plants was longer than in plants treated under the same conditions with the equivalent rate of the sodium salt.

5. The experiments have demonstrated that the rates of disappearance of 2,4-DB, its ester and 2,4-DB resulting from the breakdown of the ester depend on a variety of factors and further carefully controlled laboratory experiments would be necessary to evaluate the relative importance of these.

References

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Discussion on the four preceding papers

Mr. R. S. L. Jeater (Plant Protection Ltd.).—Does 2,4-DB have a greater effect on established lucerne than on seedling lucerne, and cause a greater setback to the crop?

Mr. Ball.—Lucerne, in both the seedling and established plant stages, receives an initial check when sprayed with 2,4-DB. It is difficult to say, from our experimental evidence, whether this check is greater on the seedling or mature plant, or whether recovery by the former is more rapid than by the latter, as the picture is complicated by two main factors: (1) the seedling plants had a much longer period in which to recover before the first cut following spraying was taken, and (2) weed competition. In our experiment, weed competition was severe in the majority of the seedling crops, but was negligible in the established crops, and in the former the removal of this weed competition far outweighed the effect of any initial check to the lucerne by 2,4-DB.

Dr. K. Holly (Oxford University Field Station).—Was any attempt made to estimate the proportion of 2,4-DB (sodium salt) which remained on the outside of the plant? With water-soluble formulations of the phenoxyacetic acids a considerable amount remains on the surface and does not penetrate. I note from Fig. I of the paper by Glastonbury *et al.* that the persistence of 2,4-DB in the plant increased with increasing dose. The greater persistence of 2,4-DB derived from the ester may therefore be merely a reflection of the much greater proportion of the 2,4-DB ester penetrating into the plant as compared with 2,4-DB sodium salt.

Miss Stephenson.—The figures given are total figures, that is in terms of the quantity of material in and on the plant.

Dr. G. S. Hartley.—Does the method of analysis used discriminate between 2,4-DB and the derived acetic compound, if any. It was at first thought that the extra selectivity of 2,4-DB over 2,4-D was due to the failure of the former to be converted to the latter in resistant species. In the present case, however, we have extensive decomposition of 2,4-DB in a resistant species. Does this therefore imply that the resistance is not due to chemical inertness but to a different and more drastic mechanism of chemical attack?

Miss Stephenson.—The method is specific for 2,4-DB; if 2,4-D were present in the material at the infra-red estimation stage, then it would have been observed in the spectrum and it would have been possible to estimate it. We have not demonstrated that 2,4-D is extracted by the technique, but because of the similarities of the properties of the two compounds, we would have expected it to be so. No 2,4-D has been observed in any of the preparations. If the decomposition of 2,4-DB does not involve the release of 2,4-D in toxic quantities, this does not invalidate the β-oxidation hypothesis, since the rate of detoxification of 2,4-D may be more rapid than its formation from 2,4-DB.

Mr. E. C. Little (New Zealand).—Is there any practical use from the observation that the amine sale of 2,4-DB is more toxic than the sodium salt?

Mr. Ball.—Although the greenhouse experiments showed that the amine formulation of 2,4-DB was more toxic to lucerne than the sodium salt, a similar effect was not observed on many weed species in greenhouse work. There did not appear to be, therefore, any practical advantage in using the amine salt in preference to the sodium salt.