THE CONTROL OF WILD OATS WITH TCA, PROPHAM (IPC) AND RELATED COMPOUNDS

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Summary

Part I:

1. TCA, dalapon, IPC(propham) and CIPC applied as pre-sowing treatments were compared in 32 field experiments on sugar beet and peas in 1955 and 1956.

2. TCA at 7.5 lb and ac at 4-6 lb propham/ac applied before sowing were found to be the most promising treatments, each of these chemicals having certain advantages and disadvantages.

Part II:

1. Performance and reliability of the TCA 7.5 lb ac pre-sowing treatment was investigated in 106 field trials.

2. The treatment was found reliable enough to be recommended for wild oat control in sugar beet and kale.

3. In peas, owing to a certain risk of yield reduction it can only be recommended on sites heavily infested with wild oats.

Introduction

The experimental work described in this report is mainly based on American and Canadian experience in the control of wild oats.

The aim of the work was to find a method which would give a satisfactory control of wild oats in a number of crops and which would be available to the farmer at the earliest possible moment to help him to deal with this increasingly serious problem.

It is realised that the method we are now able to recommend to the farmers might not be the last word in the chemical control of wild oats and that sooner or later, even more selective and more reliable treatments will probably be found.

The work developed along two lines. In one, TCA, dalapon, propham and CIPC were compared; in the other, the treatment which for various reasons was regarded as most promising was tested for its overall performance and reliability in 106 trials, the majority of which were carried out under practical farming conditions. This paper is accordingly presented in two parts.

The initial stages of the experimental work on peas were reported at the 2nd British Weed Control Conference. (1).

Part I

A comparison of TCA, dalapon, IPC (propham) and CIPC

On the basis of American and Canadian experience, TCA, dalapon, propham and CIPC were chosen as the most likely chemicals to provide an answer to the wild oat problem. The first exploratory experiments were carried out in 1954 on sugar beet and on peas (1).

Five replicated field experiments were carried out in 1955 and 27 such experiments (15 on peas and 12 on sugar beet) in 1956. In these experiments the various chemicals were compared at different times of application in relation to the sowing date of the crop.

In the 1956 experiments, wild oats did not occur at all sites but there were measurable infestations, many of them very dense, in 20 trials. Yields were taken from 10 of the pea trials; yield figures for the sugar beet trials are not yet available.

Material and methods:

Details of individual experiments are shown in the Appendix Table A. In the earlier experiments a wide range of rates was used. With increasing experience the dosage range was narrowed. Dalapon was used at half the rates of TCA. All chemicals were applied before sowing; TCA and dalapon were also applied after sowing. High volume sprays (50 or 60 gal/ac) were used throughout this series of trials. All experiments were replicated. Randomised block or split-plot designs were used.

Wild oat control in the experiments discussed in this part of the research report was largely assessed by "blind scoring", that is, scoring by more than one person not knowing the treatments of the randomized plots. In the majority of the 70 experiments discussed in the second part, the wild oats were counted. The blind scoring method was found to be as reliable as counts when both methods were used in the same experiments.

The yield figures shown refer to topped sugar beet and dry threshed peas. For pre-sowing sprays, the trials were cultivated after spraying and before sowing. This was usually done by the farmer in the course of normal seed-bed preparations.

Sugar beet experiments were hoed and singled normally except in one case (1/55) where the wild oats were allowed to grow so that detailed observations could be made. Wherever possible, pea experiments were not hoed.

Results

A. Wild oat control:

Wild oat control was assessed on 4 experiments in 1955 and on 20 experiments in 1956. The detailed figures are shown in the Appendix tables B and C but the mean percentage control figures for each year are given below (Tables 1 and 2).

Table 1: % Wild oat control - mean of 4 experiments in 1955

Time of Application	TCA lb/ac			DALAPON lb/ac			Propham lb/ac			CIPC lb/ac		
	5	10	15	2.5	5	7.5	2	4	8	2	4	8
Pre-sowing	56	63	74	54	58	85	38	50	67	43	50	71
Pre-emergence	16	36	59	42	78	93						

Table 2: % Wild oat control - mean of 20 experiments in 1956

Time of Application	TCA lb/ac		DALAPON lb/ac		PROPHAM lb/ac	
	5	7.5	2.5	3.75	4	6
Pre-sowing	55	76	35	47	49	66
Pre-emergence	64	72	44	57		

(47011)

B. Effect on crop:

Sugar beet:

In 1955 yields were taken on the beet experiment 2/55 (Table 3). Very few wild oats occurred in this field and the effect on yield is therefore due almost entirely to the treatments.

Table 3: Yield of hoed sugar beet as percentage of control

TCA lb/ac			DALAPON lb/ac			PROPHAM lb/ac			CIPC lb/ac		
5	10	15	2.5	5	7.5	2	4	8	2	4	8
99.7	97.6	86.2	101.5	94.9	88.4	96.8	94.9	74.6	89.3	61.6	35.3

Significant Difference P.05 10.7%

It appears from Table 2 showing wild oat control that 6 lb propham gives inferior wild oat control to 7.5 lb TCA. A higher dosage of propham, probably up to 8 lb would be needed to give the same wild oat control as 7.5 lb TCA. 8 lb propham, however, gave a significant yield depression of 25% while even 10 lb TCA did not depress the yield.

Peas:

In 1955 one pea experiment was harvested. The treatment yields are given below.

Table 4: Yields as percentage of control (pea experiment 3/55)

	TCA lb/ac			DALAPON lb/ac			PROPHAM lb/ac			CIPC lb/ac		
	5	10	15	2.5	5	7.5	2	4	8	2	4	8
Pre-sowing	134	139	113	110	125	104	99	111	109	92	98	92
Pre-emergence	119	101	103	119	123	100	-	-	-	-	-	-

The mean error of this experiment was high and the significant difference (P.05) was 30%.

In 1956 ten pea experiments were harvested. The treatment yields are shown in Tables 5 and 6. Statistical analysis of the figures in Table 5 showed that there was no significant difference between the TCA and propham treatments. Both treatments gave on average a significantly higher yield than untreated controls.

Table 5: Yield of peas (pre-sowing treatments) as percentage of control (10 experiments 1956)

Expt. No.	TCA lb/ac		DALAPON lb/ac		PROPHAM lb/ac	
	5	7.5	2.5	3.75	4	6
15/56	121.7	118.2	119.7	98.0	126.8	132.3
22/56	92.0	99.0	94.2	94.0	94.2	103.6
18/56	146.8	139.2	141.4	112.5	136.9	182.5
20/56	93.1	124.3	126.9	108.7	106.5	98.0
14/56	113.9	97.8	73.5	93.9	113.2	79.8
25/56	90.1	111.9	98.8	100.2	83.8	95.4
19/56	133.1	149.6	112.6	161.4	177.9	134.6
13/56	116.7	105.6	72.2	77.8	138.9	133.3
26/56	117.5	84.8	112.7	86.7	74.9	48.0
27/56	73.6	87.4	96.6	73.6	96.6	82.8
Means	109.9	111.8	104.9	100.7	115.0	109.0

Table 6: Yield of peas (pre-emergence treatments) as percentage of control (9 experiments 1956)

Exp. No.	TCA lb/ac		DALAPON lb/ac	
	5	7.5	2.5	3.75
15/56	88.4	122.7	113.1	85.4
18/56	138.4	123.2	107.2	110.3
20/56	110.6	95.0	85.1	108.7
14/56	71.1	107.0	132.8	68.8
25/56	102.7	137.5	92.0	117.7
19/56	115.0	126.0	160.6	119.7
13/56	111.1	83.3	116.7	100.0
26/56	122.6	96.9	113.0	97.9
27/56	82.8	78.2	82.8	82.8
Means	104.7	107.8	111.5	99.0

Discussion to Part I:

TCA and propham were found to be the two most promising compounds. TCA was found particularly safe on sugar beet and kale but not as safe as propham on peas.

Of all chemicals used, TCA gave the best control of wild oats. In 20 experiments the average control with 7.5 lb TCA was 76% as compared with 49% for 4 lb propham and 66% for 6 lb propham.

After considering all possible advantages and disadvantages of the two compounds, a treatment of 7.5 lb/ac TCA applied before sowing was chosen for further development.

Neither the TCA nor propham treatment are as reliable as for instance the selective control of charlock in wheat with MCPA or 2,4D, for TCA and propham have to work via the soil. The effect of any such soil treatment is dependent on many more factors and their interactions than the effect of a normal foliage spray.

The experimental results of the first part of the research report do not justify any conclusion or a correlation between any of these factors and the degree of effect of the chemicals.

A complete and final answer as to which of the two chemicals is the better could only be achieved by scientific analysis of the effect of factors such as soil type, soil structure, moisture content of the soil, rainfall before and after application, effect of time of cultivation, time of sowing, depth of sowing and the interaction of all these factors.

Even if such investigations, which would involve an enormous research effort, did lead to an explanation, it is thought doubtful whether they would be of much practical use.

With the rapidly increasing wild oat problem in British agriculture, some answer is urgently required. It was therefore felt that the most valuable approach for further work would be to test the treatment which was found to be the most reliable in the experiments described in Part I for its overall reliability under a wide range of practical conditions.

Part II deals with the results of such extensive investigations.

Part II

* Performance and reliability of TCA 7.5 lb/ac as a pre-sowing treatment in sugar beet, kale and peas (results of 106 trials)

The reasons for an extensive investigation of the overall reliability and performance of 7.5 lb TCA as a pre-sowing treatment were explained in the discussion to Part I.

A large number of simple unreplicated field trials covering the main wild oats area in England and carried out under normal farming conditions, was therefore planned.

* The authors wish to express their gratitude for the great interest and willing co-operation shown by the farmers taking part in these trials.

180 farmers were asked in the winter of 1955-1956 to co-operate in these trials, and to treat half an acre of wild oat-infested land with 7.5 lb/ac TCA, pre-sowing, to peas, sugar beet and kale. 78 farmers agreed to carry out one or more trials and 79 trials were actually sprayed by the farmers. Of these 40 trials were on peas, 34 on sugar beet, 4 on kale and 1 on beans.

No wild oats occurred on 17 of these trials but useful observations were made on the effect of the treatment on the crops.

Farmers were asked for their frank opinion of the effect of the treatment. In addition very accurate counts of wild oats were made on 50 of the experiments. On the majority of these sites the number of wild oats was counted on 40 individual randomized sample areas (2 sq. ft) on the treated plot and 40 on the untreated. On sites with a low wild oat population, larger areas were counted in order to obtain significant figures. Eighteen of the farmer trials on peas were harvested by taking 20 randomized samples from the treated and untreated areas. The sample size was 6 ft of 2 rows of peas.

The results of the 7.5 lb/ac TCA treatment of the 27 replicated experiments in 1956 described in Part I also substantially contribute to a picture of the reliability of the treatment.+

Results

A. Wild oat control:

Accurate wild oat assessment was made on 70 of the 106 trials using the methods described in Part I.

The average control was approximately 75%. It is realised, of course, that this final figure alone does not mean very much without knowledge of the variability between the individual results. The mean control figures for each experiment are therefore shown (Appendix Table D). Histograms show the frequency with which any particular degree of control occurs and therefore the probability of success and failure.

The farmers' opinions form a very important part of the results. It is, however, impossible to present all the details of the questionnaire's filled in by the farmers and the opinion of the farmers have therefore been classified as "positive", "uncertain", and "negative".

Appendix Table D shows the percentage control of wild oats on the 50 farmer trials which were counted. The density of the wild oats and a column on the farmers' opinions is incorporated in this Table. Appendix Table B (7.5 lb TCA column) gives the wild oat control of the 20 replicated experiments in 1956 which were counted.

It is worth noting how closely the mean percentage wild oat control of the farmer trial series and the series of replicated trials agree. The mean control of the farmer trials was 75.2% and of the 1956 replicated experiments 76.0%.

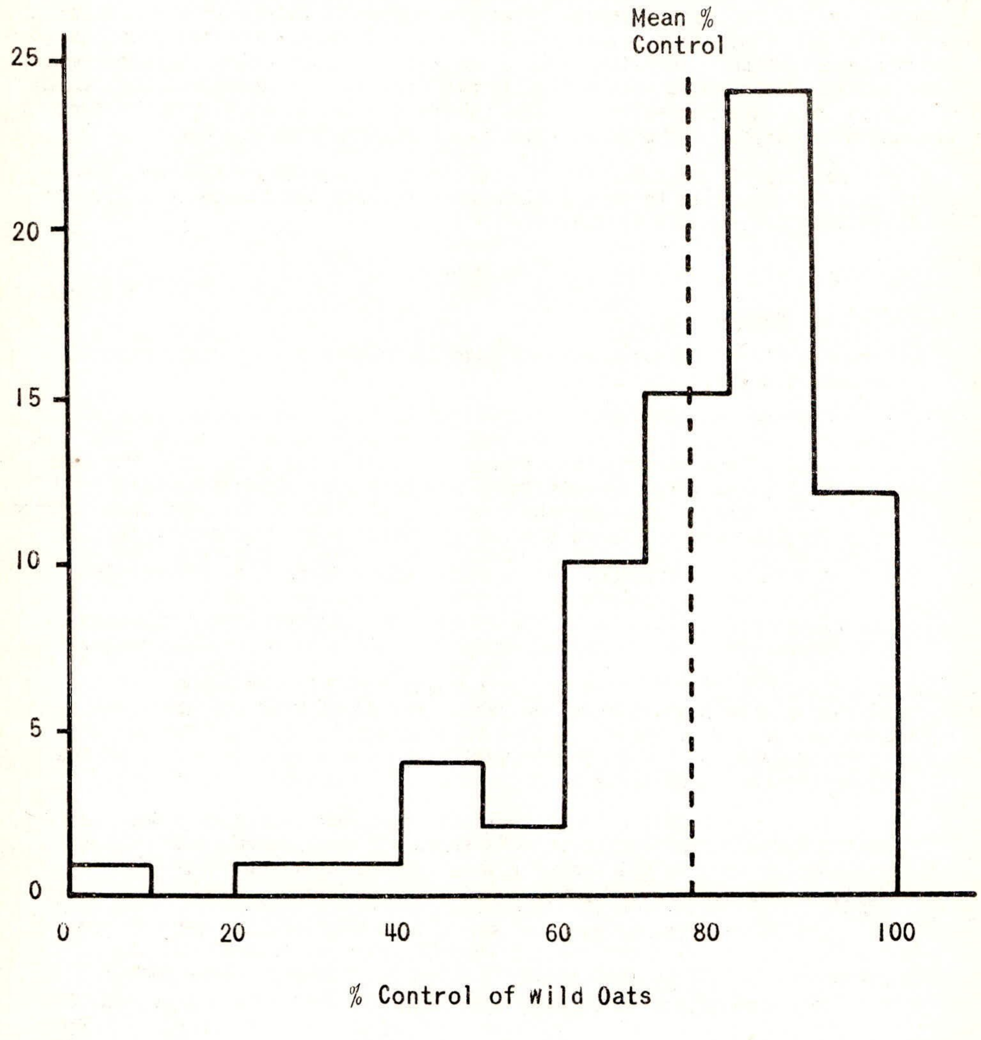
The 70 experiments carried out in 1956 were divided into 10 groups ranging from no wild oat control to 100% wild oat control and the percentage trials in each group is shown in frequency histograms 1.

The probability of getting more than 50% wild oat control is 90%
" " " " " " 60% " " " " 85%
" " " " " " 70% " " " " 70%

+ The results of 16 further trials in 1955 are reported elsewhere (2).

The probability of getting more than 80% wild oat control is 53%
" " " " " " 90% " " " " 20%

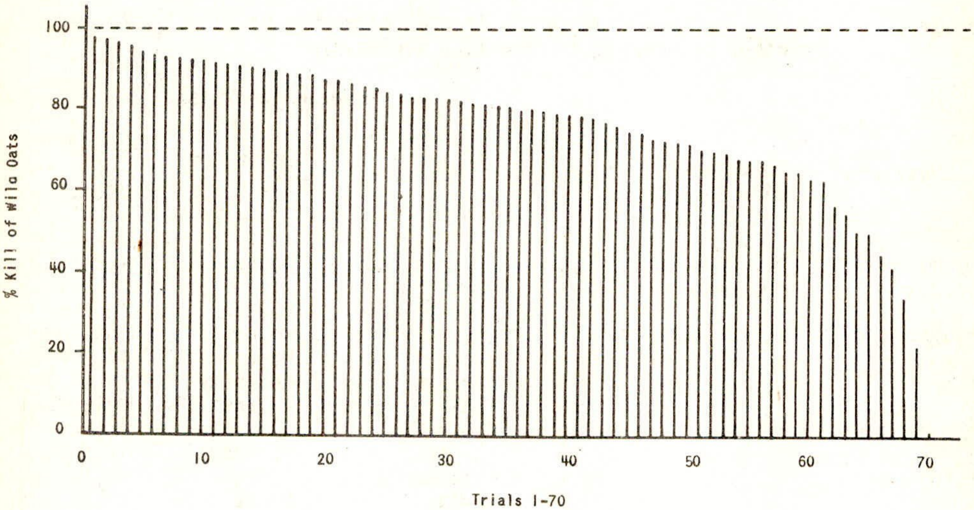
Histogram 1: Frequency distribution of 70 trials in ten categories ranging from no wild oat control to 100% control.



Histogram 2 shows the percentage of wild oat control at the 70 sites quoted in Appendix tables B and D, to illustrate the probability figures mentioned above.

Histogram 2: Wild oat control on 70 sites 1956

Each column shows the wild oat control on one site, the figures being arranged in order of decreasing wild oat control.



Trials 1 - 70

Effect on the crops:

At the time of writing, only pea trials have been harvested.

Peas:

Yields were taken at 28 sites. Wild oat infestation varied from site to site and it is therefore clear that the yield figures are influenced by a combination of the chemical effect on the crop and the effect of removing competition by the wild oats. Yield decreases are probably due to effect of the chemical on the peas, and yield increases do not necessarily indicate that there was no such effect on the crop.

Although the final mean yield figure does not indicate an effect of the treatment on the yield, approximately half the experiments show yields lower than the untreated controls. Most of these experiments were on sites with very few wild oats or on sites which were hoed. The majority of the moderately or densely infested experiments gave no yield decrease or a considerable yield increase.

These results indicate that the 7.5 lb/ac pre-sowing TCA treatment in peas cannot be regarded as safe from the point of view of pea yield. In densely infested peas where no hoeing can be done owing to close drilling the treatment is well worth using and considerable yield increases can be expected in such cases.

No definite correlation between pea variety and TCA treatment has been found. Observations however, indicate a relatively high susceptibility of Harrison's Glory as compared with other varieties, particularly Maples.

Table 6: Yield of peas treated with 7.5 lb TCA pre-sowing as percentage of untreated controls. (28 trials)

Farmer Trials			Replicated Trials		
Variety	Density of Wild Oats	Yield as % of untreated	Variety	Density of Wild Oats	Yield as % of untreated
H. Glory	Few hoed	89.7	Minerva Maple	Dense	118.2
Maples	Moderate	127.7	Canner's Perfection	V. few	99.0
Zelka (H.G.)	V. few hoed	72.6	Little White	V. dense	139.2
"	V. few hoed	78.2	Zelka	Moderate	124.3
"	V. few hoed	56.8	Minerva Maple	Moderate	97.8
"	V. few hoed	95.9	Maple	V. few	111.9
Little White	V. few	83.7	Maple	V. dense	149.6
L. Small Blues	V. dense	147.8	Marathon Maple	V. dense	105.6
H. Glory	V. few	85.4	Minerva Maple	Dense	84.8
"	Few	103.3	Maple	Dense	87.4
"	None	91.6			
Kelvedon Wonder	None	116.2			
H. Glory	Dense	93.3			
Minerva Maple	Few hoed	92.8			
H. Glory	Moderate, hoed	72.3			
Maples	Dense	90.4			
Maples	Dense	100.0			
Maples	Dense	100.0			

Sugar beet:

No sugar beet trials have yet been harvested but observations and farmers opinions indicate that there is very little risk of damage to the crop. In 18 farmer trials only one was seen where there appeared to be a slight lasting effect of the treatment on the crop. In 3 others there was a slight check to the seedlings but they recovered rapidly. At the remaining sites there was no observable effect on the beet at any stage of growth.

Kale:

No yields were taken from the 4 kale experiments but careful observations showed that there was no damage to this crop, indeed on heavily infested sites the crop appeared better on the treated area.

Beans:

Only one experiment was carried out and the results are not conclusive.

Discussion to Part II:

The results of the 106 trials suggest that certain practical recommendations can now be made:

1. For sugar beet, TCA 7.5 lb/ac applied 1 - 2 weeks before sowing, followed by cultivation. This treatment can be regarded as safe on sugar beet and there is a high probability of s satisfactory control of wild oats.

A 60 - 70% reduction in the stand of wild oats may not appear a very good control but it was found at many sites that hoeing and singling the beet on the treated areas was made very much easier and several farmers agreed that the work could be done up to 4 times faster.

2. On peas, 7.5 lb TCA applied at the same interval before sowing can only be fully recommended on heavily infested sites where no hoeing is done.

On less heavily infested peas a yield reduction of 10-20% may occur. This risk might be worth taking on farms where a determined effort is being made to eradicate wild oats by all available methods.

The TCA treatment often increases the wettability of the pea foliage and therefore the susceptibility to subsequent dinoseb sprays. This point is fully discussed elsewhere (3).

3. The TCA treatment at the same rate and time of application appears to be safe to use in kale.

References

(1) GREGORY P., REYNOLDS, J. D., & PROCTOR, J. M. (1955) Preliminary experiments on chemical control of wild Oats in peas. Proc. British Weed Control Conference, 1954, 177-184.

(2) HOLMES, H. M., GREGORY, P., & PROCTOR, J. M. (1957) Experiments with TCA for the control of wild oats in peas (Progress Report 1955). Proc. 3rd British Weed Control Conference, 1956.

(3) DEWEY, O. R., GREGORY, P., & PFEIFFER, R. K. (1957) Factors affecting the susceptibility of peas to selective dinitro-herbicides. Proc. 3rd British Weed Control Conference, 1956.

Appendix Table A

Details of field experiments 1955-1956

Year	Crop	No. of Trials	Code No.	Chemicals & Dosage Rates in lb/ac a.i.				Time of Application	No. of Replications	Plot Size
				TCA	Dalapon	Propham	CIPC			
1955	Beet	1	1/55	5 10 15	2.5 5 7.5	2 4 8	2 4 8	1. P/S+ 2. P/E*	4	sq. yd 20
1955	Beet	1	2/55	5 10 15	2.5 5 7.5	2 4 8	2 4 8	P/S+	4	20
1955	Peas	1	3/55	5 10 15	2.5 5 7.5	2 4 8	2 4 8	1. P/S+ 2. P/E*	4	20
1955	Peas	2	4-5/55	5 10 15	2.5 5 7.5	2. 4 8	2 4 8	P/S+	2 & 4	20
1956	Beet	11	1-11/56	5 7.5	2.5 3.75	4 6		1. P/S+ 2. P/E*	3	20
1956	Beet	1	12/56	5 7.5 10	2.5 3.75 5	4 6 8		1. P/S+ 2. P/E*	4	20
1956	Peas	15	13-27/56	5 7.5	2.5 3.75	4 6		1. P/S+ 2. P/E*	3	20.

NOTES + P/S = Pre-sowing application - all chemicals used.

* P/E = Pre-emergence application - TCA & dalapon only.

Spray volume in all experiments was 50 or 60 gal ac.

Appendix Table B:

Percentage control of wild oats by pre-sowing sprays

Experiments 1955: Chemical & Dosage Rate in lb ac

	TCA			DALAPON			PROPHAM			CIPC		
Exp. No.	5	10	15	2.5	5	7.5	2	4	8	2	4	8
1/55	29	35	54	35	71	87	44	55	78	44	66	88
3/55	90	88	78	70	77	76	55	40	61	33	47	11
4/55 a	58	93	95	47	37	87	52	83	100	63	17	90
b	76	71	87	76	42	97	45	89	100	85	69	100
5/55 a	55	68	74	55	71	77	16	26	32	6	61	68
b	29	26	55	42	48	84	16	10	32	26	42	68
Means	56	63	74	54	58	85	38	50	67	43	50	71

Experiments 1956:

	TCA		DALAPON		PROPHAM	
Exp. No.	5	7.5	2.5	3.75	4	6
1/56	61	84	30	31	5	51
2/56	45	84	14	10	26	41
3/56	41	83	37	4	86	87
4/56	44	66	12	7	65	74
5/56	29	34	21	54	0	30
6/56	55	90	35	55	51	87
7/56	80	76	53	53	69	57
12/56	67	88	24	47	78	89
13/56	67	81	54	74	43	63
14/56	43	67	75	71	84	96
15/56	37	44	44	40	33	77
16/56	69	85	59	70	80	75
17/56	91	98	82	92	68	82
18/56	74	90	38	59	35	68
19/56	37	72	15	78	62	66
20/56	0	54	0	0	26	26
21/56	81	92	60	64	38	44
22/56	77	95	40	87	30	69
26/56	27	70	0	17	62	68
27/56	62	68	11	21	40	67
Means	55	76	35	47	49	66

Appendix Table C:

Percentage control of wild oats by pre-emergence sprays

Experiments 1955:

Chemical & Dosage Rates in lb/ac

	TCA lb/ac			DALAPON lb/ac		
Exp. No.	5	10	15	2.5	5	7.5
1/55 a	19	32	58	38	65	86
b	25	61	70	37	80	97
c	9	43	75	38	77	96
3/55	12	8	33	56	92	94
Means	16	36	59	42	78	93

Experiments 1956:

	TCA lb/ac		DALAPON lb/ac	
Exp. No.	5	7.5	2.5	3.75
1/56	85	90	61	64
2/56	57	73	29	41
3/56	67	69	44	62
4/56	47	47	18	25
6/56	90	76	57	57
7/56	77	86	57	65
12/56	59	71	27	53
13/56	84	87	37	46
14/56	76	84	91	89
15/56	37	48	60	69
16/56	77	66	65	47
17/56	74	85	68	86
18/56	80	85	38	50
19/56	30	76	64	76
20/56	54	58	2	54
26/56	40	60	21	47
27/56	53	70	15	46
Means	64	72	44	57

Appendix Table D:

Wild oat control, wild oats density and farmers opinion in 50 farmer trials 1956

SUGAR BEET / PEAS

Expt No.	County	%Kill of Wild Oats	Density per sq. yard	Farmers Opinion	Exp. No.	County	%Kill of Wild Oats	Density per sq. yard	Farmers Opinion
1	Cambs	77.8	182.1	Positive	24	Cambs	80.4	203.1	Negative
2	Cambs	78.1	91.2	Positive*	25	Cambs	89.1	27.8	Positive
3	Cambs	93.1	157.0	Uncertain	26	Cambs	92.3	71.2	Positive
4	Cambs	71.7	190.1	Positive	27	Herts	84.9	<1.0	Uncertain
5	Herts	90.0	99.7	Positive	28	Essex	66.6	97.2	Positive
6	Essex	69.1	103.0	Positive	29	Essex	71.1	73.5	Uncertain
7	Essex	88.3	78.5	Positive*	30	Essex	96.7	211.8	Uncertain
8	Essex	90,7	12.0	Uncertain	31	Essex	22.4	<1.0	Negative
9	Essex	69.2	131.7	Positive	32	Essex	49.1	9.8	Negative
10	Essex	70.5	71.0	Positive	33	Essex	88.1	55.6	Negative
11	Essex	81.0	186.1	Positive	34	Essex	85.8	98.1	Negative
12	Essex	81.7	42.3	Positive	35	Suffolk	79.0	83.9	Positive
13	Essex	63.8	9.6	Negative	36	Norfolk	89.0	28.6	Positive
14	Essex	74.5	40.6	Positive	37	Norfolk	64.0	<1.0	-
15	Essex	62.0	10.4	Positive	38	Northants	61.9	106.4	Uncertain
16	Suffolk	77.6	17.1	Positive*	39	Lincs	82.8	1.8	Positive
17	Suffolk	86.8	208.9	Uncertain	40	Lincs	0.0	2.2	Negative
18	Suffolk	95.6	127.0	Positive	41	Lincs	86.8	30.7	Negative
19	Suffolk	79.8	43.8	Positive	42	Lincs	92.9	<1.0	Uncertain
20	Norfolk	91.8	46.5	Positive	43	Lincs	49.0	4.8	Negative
21	Lincs	81.3	7.8	Positive	44	Lincs	82.3	<1.0	-
22	Lincs	80.6	23.4	-	45	Lincs	92.0	<1.0	-
23	Warwick	40.9	1.0	Uncertain	46	Yorks	56.3	1.7	-

* These farmers are not prepared to give a definite opinion until the beet have been lifted.

KALE / BEANS

47	Cambs	74.8	13.5	Positive	50	Suffolk	77.3	212.1	Negative
48	Essex	83.4	74.5	Positive					
49	Essex	74.0	7.9	Positive					

THE RESULTS OF LABORATORY TESTS WITH HERBICIDES FOR PRE-EMERGENCE USE IN SUGAR BEET, WITH PARTICULAR REFERENCE TO AVENA FATUA

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Summary

In 4 experiments various herbicides were tested for their selectivity during the germination phase between sugar beet and rape, and sugar beet and Avena fatua, using a germination technique in petri dishes, whilst one experiment was carried out in the greenhouse, comparing the effects of pre-emergence application of 3 herbicides on the seedling establishment of sugar beet, Avena fatua and other species. The techniques are described, conclusions are drawn concerning the relative selectivities of the chemicals and the value of these conclusions is discussed in relation to the results of field experiments.

Introduction

The need for chemical means of controlling weeds in sugar beet and the results of field experiments with various compounds have been discussed in research reports to both previous British Weed Control Conferences (4) (5). The conclusions in those reports and from further field work since, have been that there is no immediate prospect of finding any more easily applied and reliable substitute for sodium nitrate as a post-emergence spray. This fact has led to an emphasis on testing pre-emergence herbicides. Pentachlorophenol (PCP) in oil emulsion is one of these and as a contact pre-emergence treatment it has proved successful where rapid germination of weeds (especially Sinapis arvensis and Raphanus raphanistrum) is experienced. Where slower germination of weeds occurs, however, this type of treatment may be very difficult or impossible to time successfully and much effort has gone towards finding a reliable residual pre-emergence treatment. Such a method might prove almost ideal for weed control in sugar beet, weeds being controlled for the important first few weeks of growth and economy being possible by restricting spray application to bands only over the rows.

In the course of conducting field experiments however, it was found difficult to obtain critical comparisons of residual pre-emergence weedkillers because of (i) irregular germination and development of sugar beet, (ii) unpredictable distribution of weeds on trial areas and (iii) the enormous influence of soil factors. Furthermore it was impossible to handle more than a few chemicals in any one trial.

It was found useful, therefore, to carry out certain laboratory and greenhouse experiments during the relatively short interval between completion of sugar beet harvest in December and the beginning of drilling in March, in order to screen pre-emergence herbicides before use in the field. In this manner it was possible to reduce the number of chemicals to be tested, and also to obtain some idea of their "true" selectivities, undistorted by the spatial separation of beet and weed seeds which inevitably affects selectivity in the field.

Experimental Methods

The "10 day germination" method used in the first 4 experiments has already been described by Blackman (1952)(1) and consists of germinating seeds of the test species in petri dishes, under a layer of sand moistened with the toxic solution. In all cases moderately coarse sterile sand was used. The exact quantities of sand and added toxic solution varied slightly in the different experiments but the aim was to make a layer of approximately 1 cm depth over the seeds, leaving a small air space between sand surface and lid and to bring the sand to a thoroughly moist but non-saturated state. When water-soluble compounds were used, the seeds were placed in the bottom of the dish (the two or more test species being mixed together) and the appropriate volume of sand (c 75 ml or 100 grs), first moistened with the toxic solution (c 16 ml) and shaken up in a separate dish, was then placed on top of the seeds and pressed down level. With water-insoluble compounds, solutions were made up in acetone and the appropriate quantity applied as evenly as possible to each dish of sand. The acetone was then evaporated off at room temperature, usually taking 1 to 2 hours in a cool draught. When no trace of acetone was detectable, the sand was then moistened with the correct quantity of distilled water, mixed and placed over the seeds in the same way. Acetone controls, treated in this way showed no difference from those treated directly with water.

Incubation was normally at 25°C in the dark and counts were made 8 to 10 days after sowing. Emergence of the seedlings through the sand was normally taken as a criterion of "germination" and this germination, expressed as a percentage of that on controls, was plotted against the concentration of toxicant on a log scale. In experiment 4, however, root shoot and total lengths were measured and it is the mean total lengths of all germinated seedlings that are used in the results of that experiment.

Experiment 5 was a "40 day germination test" carried out in the greenhouse and was designed to assess the effects of herbicides on growth of seedlings beyond the immediate germination phase, up to a longer period beyond emergence. Shallow tins, 6½" x 5" x 2½" were filled with an almost dry gravelly sand mixture, seeds of the test species being sown at ¾" or ⅜" depth. Application of the chemical was then made to the surface in a large volume (230 ml) of tap-water. This was done from a measuring cylinder, preliminary observations with water and with solutions of tartrazine having suggested that the distribution of a water soluble compound should be sufficiently uniform and the final moisture of the sand about optimum by this method.

To avoid competition, the two main test species in Experiment 5 were sown in separate series of tins. All the tins were covered with bituminized paper to restrict evaporation before emergence of the seedlings, but after removal, there was considerable drying out and surface watering had to be carried out - just sufficient to wet sand without causing any appreciable drainage from the tin. Temperature was first at 12°C and later 15°C. At the latter temperature evaporation was rather rapid and ideally, the humidity should be kept higher than was possible in this experiment.

The rates of chemical in experiments 1 to 4 are all expressed in parts per million of toxic solution and take no account of the sand swelling the total volume or mass of the medium.

In experiment 5 the rates are on a per acre basis, the actual concentrations of solution added being e.g. for 4 lb per acre c. 900 ppm.

Most chemicals were technical grade materials and sources are listed at the end of the report.

Experimental Results:

Experiment 1 (1953). Selectivity of 6 herbicides between sugar beet and rape.

Details: In petri dishes; 75 ml sand, 18 ml solution.

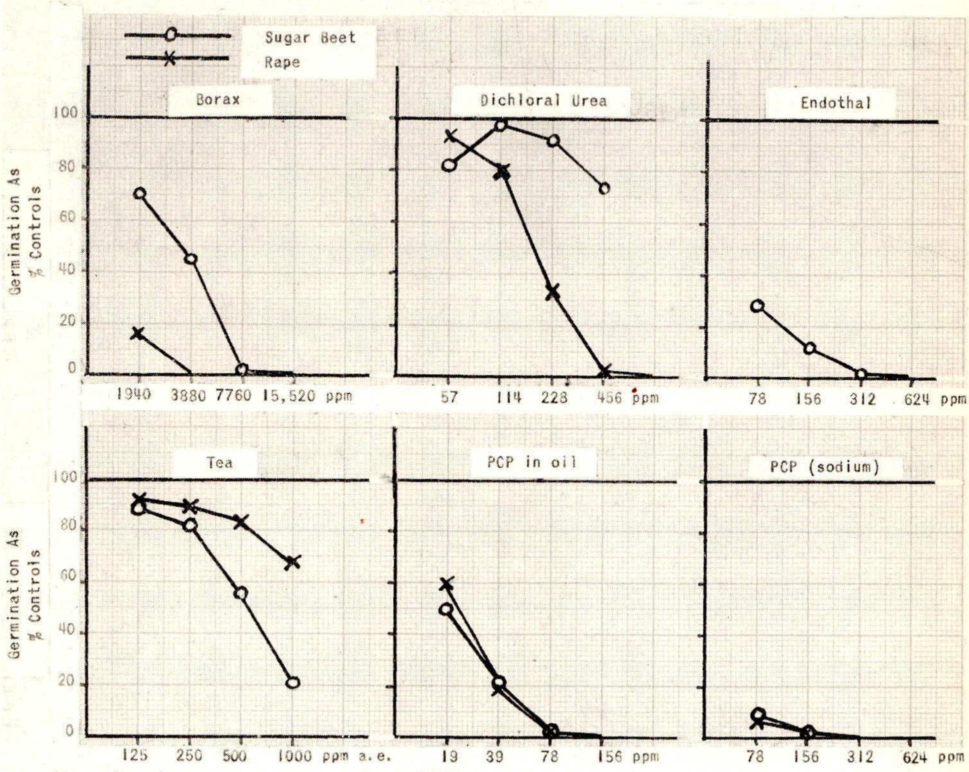
Incubation: 7 days at 25°C.

Test plants per dish: 50 seeds of Turnip Rape var. Nida
(Brassica campestris)
25 rubbed sugar beet "seeds".

Chemicals: Borax.
Dichloral Urea.
Disodium 3, 6-endoxohexahydrophthalate (Endothal).
Sodium pentachlorophenate (PCP) (Sodium)
Pentachlorophenol in oil (PCP).
Sodium trichloroacetate (TCA).

Results: see Figure 1.

Fig. 1. The Effect of Six Herbicides on the Germination of Sugar Beet and Rape in the 10 Day Germination Test.



% Germination in Control Dishes:- Rape = 82%
Sugar Beet = 102% (i.e. 102 Sprouts per 100 Clusters)

Discussion:

Borax was included in this test following an encouraging report by Kaudy et al. (3). The results indicate some definite selectivity between sugar beet and rape but unfortunately 3 field trials in 1954 did not include any weeds of the Brassica family. In general the conclusion was that any selectivity against weeds at the germination phase was offset by stunting effects on the beet which occurred at a later stage of development, and no further field work was considered justifiable.

Dichloral Urea showed considerable selectivity but in a subsequent field trial (4), it displayed very little activity even at 16 lb per acre against the dicotyledenous weeds present. Both laboratory and field experiments however do confirm considerable tolerance of beet to dichloral urea and its effect on various grass weed species as well as Brassica spp. should be tested further.

Endothal was very active and some selectivity was suggested but in a field experiment at Rackheath in 1954 (2) there was little or no selectivity displayed against wild radish (Raphanus raphanistrum), and as with Borax, too large a proportion of the toxicity is manifested after the germination phase to make results from this type of laboratory test reliable. Endothal did show some interesting selectivity to certain other weeds in field trials but its dependance on soil moisture and its toxicity to humans has discouraged further use. TCA (sodium) showed actually greater toxicity to sugar beet than to rape, and although in the discussion of Experiment 3 it is decided that the results of this type of test with TCA are unreliable, in fact it has been confirmed in field experiments that Brassica spp. may have at least as much tolerance to TCA as sugar beet.

The results with PCP in oil emulsion and PCP (sodium) were interesting in showing no selectivity at all, and both in this respect and in the relative activities of the two formulations, the results correspond very closely with those from field trials: no weeds show any inherent resistance or susceptibility and in the absence of spatial separation of weeds and beet, or differential timing of the spray, it has been shown that beet have no innate resistance either.

Experiment 2 (1954). Comparison of toxicities of propham and CIPC to sugar beet and Avena fatua.

Details: In petri dishes: 78 ml sand, 15 ml water.

Incubation: 10 days at 27°C.

Test plants: 30 seeds of Avena fatua (picked to encourage germination).
30 rubbed sugar beet "seeds".

Chemicals: O-isopropyl N-phenylcarbamate (IPC, propham).
O-isopropyl N-(3-chlorophenyl) carbamate (CIPC).
Each chemical at 9 rates.

Results: The following table indicates the concentrations required to cause 90% inhibition of germination with each chemical.

TABLE 1

	Sugar beet	Avena fatua	Ratio S.B./A. fatua
propham	> 64 ppm	< 2.5 ppm	> 25.6
CIPC	10 ppm	1.5 ppm	6.7
Ratio propham/CIPC	> 6.4	< 1.7	

Discussion:

The rates used in this experiment were unfortunately too high to obtain the LD 50s on *Avena fatua* and even LD 90 appeared to fall below the lowest rate (2.5 ppm) of propham used. A comparison of LD 90s, though not to be considered very accurate, does clearly indicate the greater selectivity of propham.

These results from a laboratory experiment with two chemicals with similar structure and, presumably with similar modes of action, mainly at the germination phase, persuaded the author to concentrate on testing propham in field trials in preference to CIPC. This decision has been justified by the findings of other workers e.g. (2) and proved the usefulness of this technique, at least in such a case as this where similar chemicals, both acting largely on the germination phase, were to be closely compared.

Experiment 3 (1955). Comparison of the relative toxicities of four chemicals to sugar beet and *Avena fatua*.

Details: In petri dishes: 65 ml sand, 15 ml water.

Incubation: 8 days at 25°C.

Test plants: 25 *Avena fatua* seed (pricked).
25 natural sugar beet "seeds" (dressed with TMTD).

Chemicals: O-isopropyl N-phenylcarbamate (propham).
O-isopropyl N-(3-methylphenyl) carbamate (N5518).
α chloro-N, N-diethylacetamide (pure) (CDEA).
sodium trichloroacetate (TCA).

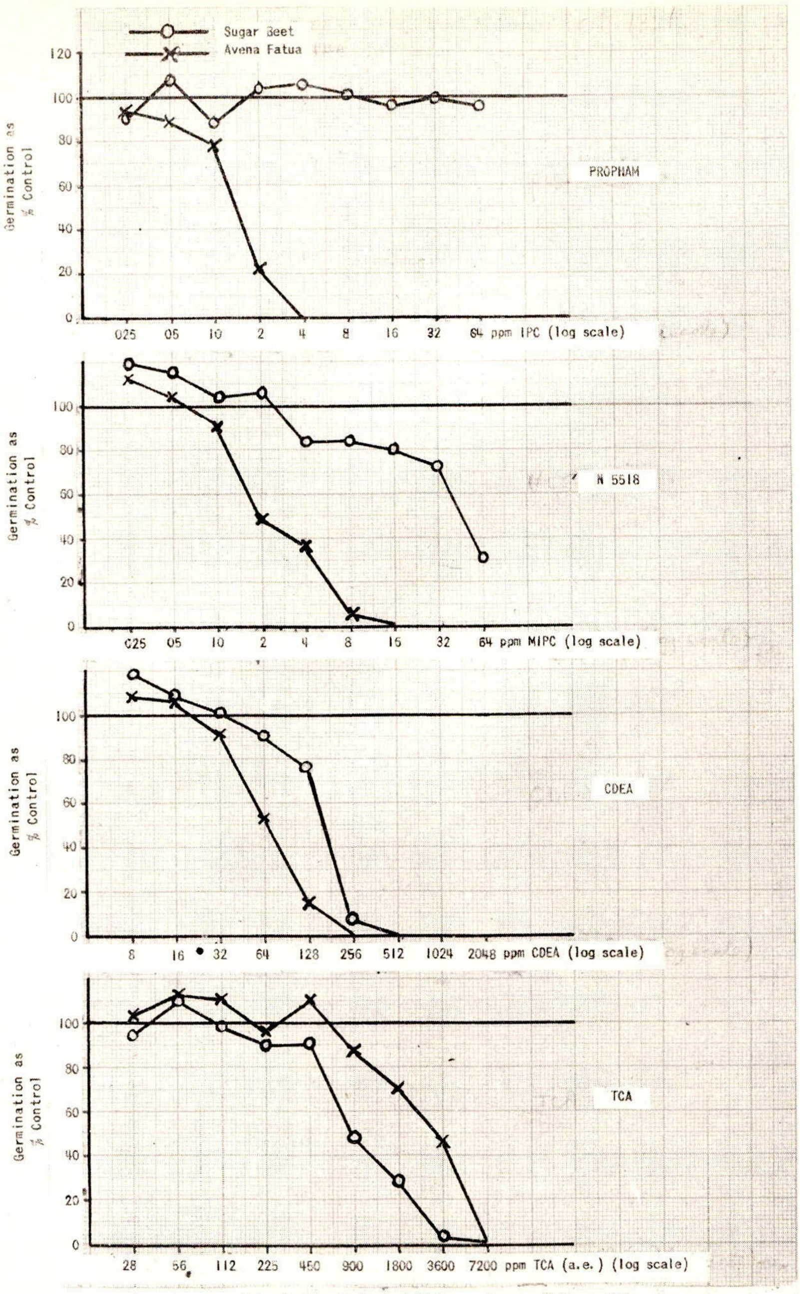
Results: See Figure 2.

Discussion:

Results suggest that propham is more selective with these species than N5518. Field work in 1956 has confirmed the greater toxicity of N5518 to sugar beet and there is no evidence from other workers that it will provide a better kill of *Avena fatua*.

It should be noted that the apparently enormous selectivity of propham is not borne out quite so strikingly in the field-partly due to the difficulty of incorporating the chemical in the soil and bringing the relatively insoluble compound into close contact with the *Avena fatua* seeds, but partly also to the effect of IPC on subsequent growth of the beet which may be quite severely stunted for several weeks. For instance in a greenhouse experiment in 1956 it was observed that a rate of IPC equivalent to 9 lb per acre worked into a 2 inch depth of soil in tins caused no mortality of beet, and cotyledon fresh weights were slightly greater than on control tins. Fresh weights of true leaves (first pair), however, 40 days after sowing were only 45% of those on controls. In the same experiment a rate of 1 lb per acre worked into the 2 inch layer of soil

Fig. 2. Comparison of the Relative Toxicities of Four Chemicals to Sugar Beet and Avena Fatua in the "10 Day" Germination Test.



% Germination in Control Dishes:- Avena Fatua 77%

Sugar Beet 132%

(47011)

provided complete control of Avena fatua, a result suggesting that highly selective results might be obtainable with low rates of IPC in the field were it possible to ensure a more thoroughly uniform distribution of the herbicide in the soil.

CDEA in this experiment showed only slight selectivity and TCA showed the reverse, but reports of field work in the previous season (1954)(5) suggested that both had in fact definite selective value in the field, and they were included in field trials in spite of the laboratory results. These field trials did confirm field selectivity - not very great with CDEA (or the related CDAA) but decidedly promising with TCA and it is clear that the use of germination technique for these two chemicals was decidedly misleading. Rates of TCA affecting germination of beet may allow normal germination of Avena fatua but subsequent growth of the grass may be completely stopped at lower rates which do not affect the beet.

Experiment 4 (1956). Comparison of the relative toxicities of ten carbamates to sugar beet and Avena fatua.

Details: In petri dishes: 85 ml sand, 18 ml water.

Incubation: 11 days at 25°C.

Test plants: 10 rubbed sugar beet "seeds" (TMTD dressed).
per dish 10 Avena fatua seed (pricked).

Chemicals:
O-isopropyl N-phenylcarbamate (propham).
O-isopropyl N-(3-chlorophenyl) carbamate (CIPC).
2-chloroallyl diethyldithiocarbamate (CDEC).
O-isopropyl N-(3-methylphenyl) carbamate (N5518).
O-isopropyl N-(3-methoxy, 5-chlorophenyl) carbamate (T518).
sec. butyl-N-(3-chlorophenyl) carbamate (N5519).
2-chloroethyl N-(3-chlorophenyl) carbamate (N5520).
(1-chloropropyl-2) N-(3-chlorophenyl) carbamate (N5521).
(1-chloropropyl-2) N-(3-methylphenyl) carbamate (N5522).
2-chloroethyl N-(3-methylphenyl) carbamate (N5523).

Results: See Figure 3 and 4.

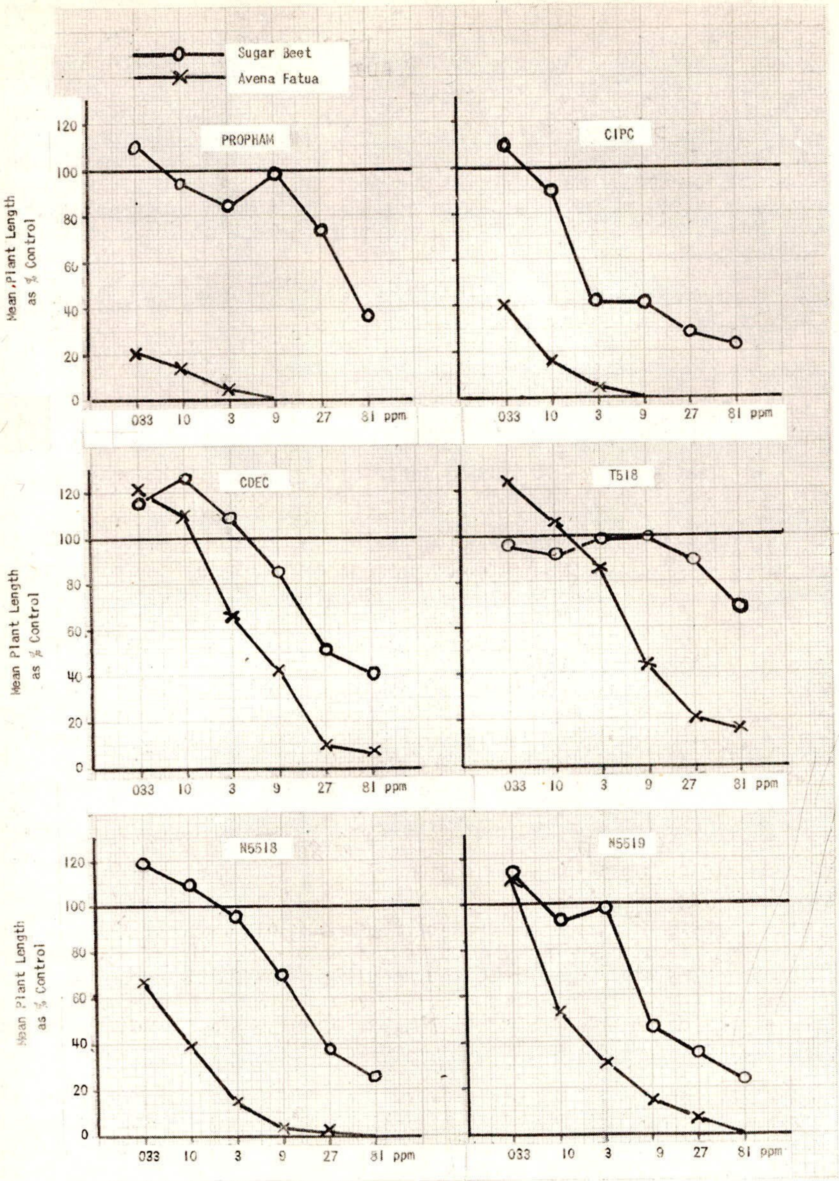
Discussion:

In this experiment, lower numbers of seeds were used and of these a rather small proportion of wild oat germinated so the usual criteria of "germination" were not used. Instead, all germinated seedlings (including those not emerging through the sand) were measured for root, shoot and total lengths. The graphs are based on the mean total lengths of germinated seedlings expressed as a percentage of those in the control dishes.

A direct comparison of the selectivities of these ten carbamates results in the conclusion that none are apparently superior to propham and consequently none have been tested further in the field for control of Avena fatua with the exception of CDEC. The latter shows a relatively slender selectivity in this test but in the field shows selectivity very similar to that of propham. There appears to be some difference in the mode of action of CDEC, it apparently being restricted more exclusively to the germination phase than propham.

All other carbamates, though only tested as surface applied pre-emergence treatments in the field showed similar relative toxicities to sugar beet as

Fig. 3. A Comparison of the Relative Toxicities of Ten Carbamates to Sugar Beet and Avena Fatua in a "10 Day" Germination Test.

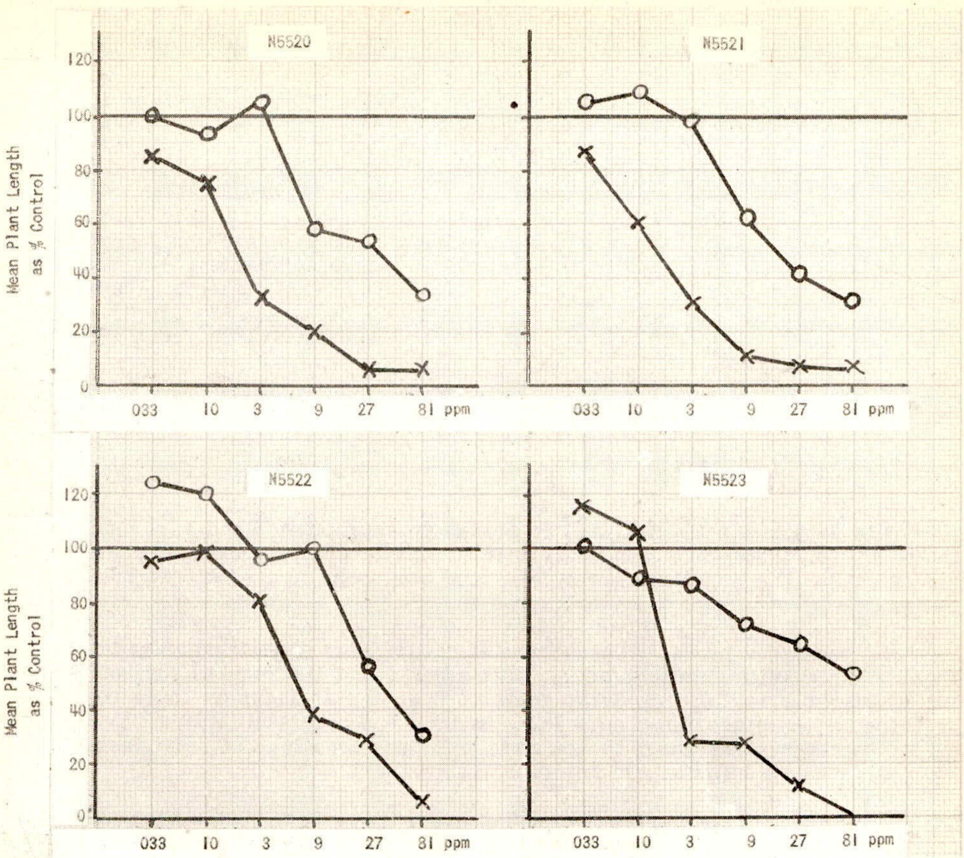


% Germination in Control Dishes: Avena Fatua 39%
Sugar Beet 116%

Mean Plant Lengths in Control Dishes: Avena Fatua 13.4 cm
Sugar Beet 5.5 cm

(47011)

Fig. 4. Further results of Expt. 4. continued from Fig. 3.



shown in this test, i.e. least toxicity from CDEC and T518, moderate toxicity from propham, N5522 and N5523 and greatest toxicity from N5518, N5520 and N5521.

Root and shoot lengths showed that except with CDEC Avena fatua roots were stunted more readily than the shoots.

With sugar beet, results were inconsistent but propham, CDEC and T518 did have an apparently distinct tendency to increase relative and actual lengths of root. This effect was most marked at non-toxic levels and occurred at lower levels of several of the other carbamates. It is not possible to ascertain the full significance of these effects but it is interesting to note that the least toxic to beet are those chemicals causing an apparent stimulation to root growth at non-toxic levels.

Experiment 5 (1956). Comparison of the toxicities of three chemicals towards sugar beet, *Avena fatua* and several other species.

Details: In shallow tins in greenhouse 2¼ inch depth of gravelly sand + 230 ml solution.

Incubation: 37 days, first at 12°C later at 15°C.

Test plants per tin: series (i) 30 rubbed sugar beet "seeds" (TMTD dressed).
" (ii) 30 *Avena fatua* seed (pricked).
" (iii) 10 each of *Alopecurus agrestis* (Black-grass).
Lolium italicum (Rye-grass).
Brassica rapa (Turnip).
Papaver somniferum (Poppy).

Chemicals: sodium trichloracetate (TCA).
sodium 2,2-dichloropropionate (dalapon).
sodium 2,2,3-trichloropropionate (2,2,3-T).

Results: See Figure 5.

Discussion:

This experiment was designed to follow up experiment 3 and test a technique for those chemicals whose main effect is clearly not on the germination phase. The principle was to grow the plants on to a much more advanced stage.

The technique proved very successful in spite of some difficulty in keeping the moisture content of the tins steady, and the results suggest that TCA is almost certainly the least toxic to beet and at least as toxic to *A. fatua* as the other two chemicals. Dalapon had a particularly serious effect on the beet as shown by the mean true-leaf lengths. On the whole 2,2,3-trichloropropionic gave intermediate results.

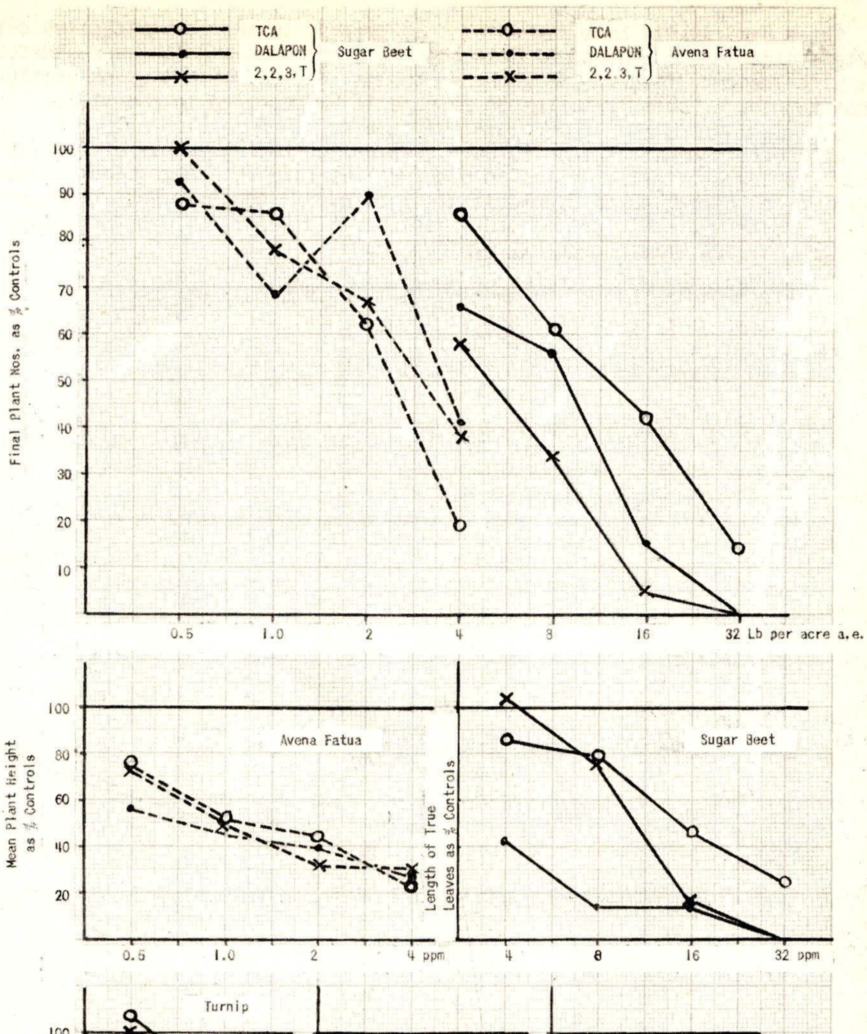
Although the major effects of dalapon and 2,2,3-T on germination and height of *Avena fatua* resembled those of TCA, it was noted that both had a greater tendency to cause tillering at sublethal doses than did TCA - this is in agreement with the recognised theory that dalapon at least is more readily translocated than TCA and may cause more widespread physiological response in the plant.

The generally greater selectivity of TCA between dicotyledons and grasses is supported by the results with poppy and turnip (fresh weights of turnip seedlings were reduced 83% by 4 lb dalapon per acre, only 39% by 4 lb TCA) and ryegrass.

The more important effect of these chemicals in a pre-drilling application such as this is almost certainly the acute toxicity rather than the chronic systemic effect, so dalapon has none of the advantages that it might have over TCA in a post-emergence application.

The actual degree of selectivity obtained in this experiment was not very great and whilst field results with TCA have in general shown a high degree of safety, some caution is probably necessary on really light sandy soils.

Fig. 5. A Comparison of the Toxicities of Three Chemicals towards Sugar Beet, Avena Fatua and other Species.



Final % Emergence on Control Tins: Sugar Beet 94%
Avena Fatua 68%

Conclusions:

These experiments have suggested that propham is the most selective carbamate available for control of wild oats in sugar beet and it is considered that with the exception of CDEC, these results obtained with a quick germination technique bear a useful relation to results to be expected in the field.

With other chemicals the "10" day" germination technique may give misleading results, owing to its limitation to observations only on the germination phase. Suggested selectivities of dichloral urea, borax and endothal between sugar beet and a Brassica sp. could not be confirmed in field experiments and results obtained with TCA were thoroughly misleading.

The "40 day" technique, using tins in the greenhouse was better for chemicals other than carbamates and might even have been preferable with those, were it not for problems of space, heat and humidity control in greenhouses during the winter months when these experiments were carried out.

From trial 5 it was concluded that TCA was more selective than dalapon or 2,2,3-trichloropropionate between sugar beet and Avena fatua. Selectivity was also indicated in favour of turnip and against Alopecurus agrestis. Ryegrass was susceptible to all three chemicals.

A point brought out clearly in this work is that the modes of action of residual pre-emergence herbicides may be distinctly varied and a classification might be considered into those with effects on the germinating seed and those with effects on the established seedling.

Sources of chemicals:

Borax, (granular) from Borax Consolidated Ltd., London.

Dichloral urea, (E.H.2) from Carbide and Carbon Chemical Corp. New York, U.S.A.

Endothal (Me 3003) from Niagara Chemical Division, Middleport, U.S.A.

CDEC, PCP and PCP (sodium) from Monsanto Chemicals Ltd., London.

TCA (sodium) from Kaylene Ltd., London and from du Pont de Nemours and Co. Inc., Delaware, U.S.A.

Dalapon from Dow Chemical Co., U.S.A.

2,2,3-T. from American Cyanamid Company, U.S.A.

CDEA synthesised by Department of Agriculture, Oxford.

CIPC from Metallurgical Chemists Ltd., London.

propham from Pal Chemicals Ltd., London.

N5518-N5523 from Niagara Chemical Division, Middleport, U.S.A.

T518 from U.S. Industrial Chemicals Co., U.S.A.

References:

1. Blackman, G. E. (1952). Studies in the Principles of Phytotoxicity. 1. The Assessment of Relative Toxicity J. exp. Bot. 3 (7) 1-27.

2. Ebell, L. F. (1954). Progress report on Chemical Control of Wild Oats. Proc. 7th W. Canad. Weed Control Conf. 32-39.

3. Kaudy, J. C., Berger, K. C. and Truog, E. (1952). Borax applications to canning and sugar beets for the control of weeds. Agron. J. 44 (8) 409-411.

4. Parker, C. (1954). Experiments with various pre- and post-emergence chemical treatments for weed control in sugar beet. Proc. Brit. Weed Control Conf. 1953 274-281.

5. Parker, C. (1955). Chemical weed control in sugar beet: a report of experimental work in 1954. Proc. Brit. Weed Control Conf. 1954, 447-454.

Acknowledgments:

The author wishes to acknowledge that this work was part of a programme of investigation into chemical weed control in sugar beet, financed by the Sugar Beet Research and Education Committee. He wishes to thank Professor G. E. Blackman for the facilities provided in the Department of Agriculture at Oxford and further to thank Professor Blackman, Dr. E. K. Woodford, Dr. K. Holly and other members of the Unit of Experimental Agronomy at Oxford who advised and assisted in the conducting of the work, and in the writing of this report.

Text Figure Legends

Figure 1. The effect of six herbicides on the germination of sugar beet and rape in a "10 day" germination test.

(% germination in control dishes: rape 82%, sugar beet 102% (102 sprouts per 100 clusters)).

Figure 2. A comparison of the relative toxicities of four chemicals to sugar beet and *Avena fatua* in a "10 day" germination test.

(% germination in control dishes: sugar beet 132%, *Avena fatua* 77%).

Figure 3. A comparison of the relative toxicities of ten carbamates to sugar beet and *Avena fatua* in a "10 day" germination test.

(% germination in control dishes: sugar beet 116%, *Avena fatua* 39%. Mean plant lengths in control dishes, sugar beet 5.5 cm, *Avena fatua* 13.4 cm).

Figure 4. Further results of Experiment 4 continued from Figure 3.

Figure 5. A comparison of the toxicities of three chemicals towards sugar beet, *Avena fatua* and other species.

(Final % emergence on control tins: sugar beet 94%, *Avena fatua* (68%).

DISCUSSION ON THE PAPERS AND RESEARCH REPORTS ON WILD OATS

Miss J. M. Thurston (Introduction to discussion)

I have listened to the papers and read the Research Reports with great interest and there are a number of points on which I, as a botanist, should like to comment.

I heartily agree with Mr. Dadd's conclusions that research is needed on the effect of the combine on the multiplication and dispersal of weeds. The study could profitably be extended to include the effect of quick and deep ploughing with modern machinery and to include other weeds besides wild oats, I also agree that cultivations are bound to be important in controlling wild oats and that the general method of attack will be the same for both species. however, the best time to cultivate will depend on the species because they differ in periodicity of germination. In fields containing both, injudicious alterations in the time of cultivation may alter the proportion of the two species without reducing the number of wild oats present. It is also worth remembering that however many seedlings of A. fatua are destroyed in autumn, far more will appear in the following spring from the larger second peak of germination.

The need for seed-corn free of wild oats is great, but can we produce enough for the whole country? I doubt it, but my work lies mainly in the worst infested areas and I should be interested to hear what an unbiassed observer such as our Chairman has to say.

One more small point - the wild oat seeds from the crop of one of Mr. Dadd's pigeons were tested at Rothamsted and were not viable, so that pigeon was controlling and not spreading wild oats.

(I think I refrained from commenting at the time on the "risk" Mr. Dadd was taking in "anticipating the results of the Boxworth experiment" on the survival of wild oats under ley and also omitted any comments on the place of the ley in wild oat control, as this seemed premature with the experimental evidance still incomplete).

My comments, from the biological standpoint, on the five research reports introduced by Dr. Pfeiffer, are:-

1. As a result of holding this conference early in November, most tables of results have to appear without estimates of significant differences. Significant differences in field experiments are often high owing to the patchy distribution of the weeds and I think this will be so in two sets of figures where the results are somewhat erratic. This may mean that some of the less successful treatments do not show significant control of wild oats, though the most successful treatments will probably be vindicated.

2. We now have a choice of at least 3 promising chemicals for control of wild oats in broad-leaved crops and when the conditions governing their effectiveness are fully understood they should prove most useful, the farmer or contractor selecting the compound best suited to his conditions. Only Dr. Blackett offers us any hope of controlling wild oats in cereals. If his eye-estimates of crop yields can be confirmed by actual figures for

the yield and viability of seeds of treated cereals many people will be anxious to try CDAA and CDEC. He has only been engaged in this work for about a year and it is understandable that he could not get complete results on everything in one season. I feel sure that cereal yields on treated plots are already on next season's programme of work. There is another point which I should like Dr. Blackett to clear up. I have heard that chloroacetamides are unpleasant substances to work with. What is their mammalian toxicity and does it affect their suitability for use on farms?

3. Where it is necessary to increase the period between applying a herbicide to the soil and sowing the crop, it would probably be better to delay sowing rather than to spray earlier, as there is a risk that if the chemical is applied too early it may have worked out before the peak of wild oat germination is reached. All the compounds discussed seem to affect only the seedling and not the dormant seed.

4. The relation of soil type to effectiveness of herbicides applied to it is bound to be complex. We must consider the interaction of soil properties with the herbicide and also with the weed-seeds. For example, drought might delay germination, as well as hindering the diffusion of the herbicide through the soil.

5. Messrs. Proctor and Armsby doubted if cultivation stimulated germination of wild oats. This has been proved at Rothamsted and in Canada on heavy and compacted soil but results might be different on a loose, light soil especially during drought.

6. The percentage control of wild oats is usually expressed on a per plant basis, but the figure that interests the farmer is the reduction in the number of dormant and viable wild oat seeds put back into the soil. Where a heavy infestation is only partly controlled, the survivors might grow extra large in the absence of competition from the others and contribute as many seeds per Sq. yd as the untreated plots. For instance, Miss Holmes and Dr. Pfeiffer quote a farmer who was uncertain of the value of killing 97% of the wild oats in a field with over 200 plants per sq. yd. If the remaining 6 plants per sq. yd grew huge this would be understandable, but Dr. Pfeiffer showed us (With Mr. Dadd's slides) that the survivors of TCA treatments are so stunted that they scarcely produce seeds. This makes even a 75% kill of plants well worthwhile. Mr. Parker pointed out the distinction between killing and stunting plants.

7. It is good to know that TCA was just as effective when applied by farmers as when used by a research team. It is a pity that this substance de-waxes peas, rendering them more susceptible to dinoseb and even, so I have heard, to drought. However, as varietal differences in susceptibility have been found and there is a great demand for crops suitable for inclusion in a cleaning-rotation, might it not be economic to breed a pea variety for the purpose? The figures for relative cost of weeding peas with and without TCA quoted by Messrs. Proctor and Armsby are a valuable contribution on the economic side.

8. Finally, I am sorry that Mr. Parker is not here to tell us why he grew *A.fatua* at 25°C (= 77°F). This is well above air or soil

temperatures in March or April in Britain and might affect the susceptibility to herbicides, thus reducing the value of laboratory screening-tests.

Dr. R. D. Blackett (Introduction to discussion)

Dr. Pfeiffer, in his very interesting paper, has given a comprehensive picture of the chemical approach to the wild oat problem.

Considering now the degree of success attained in the two main lines of investigation, namely:- wild oat control in broadleafed crops such as sugar beet and peas; and wild oat control in cereals.

In sugar beet there is the first definite recommendation for a chemical means of wild oat control.

With regard to peas, TCA has again given a high degree of weed control, but there seems to be some doubt as to whether this compound is safe to use on peas in view of possible crop damage.

Mr. Proctor and his colleagues of the Pea Growing Research Organisation have indicated that by early spraying and sowing in widely spaced rows to allow weed control by mechanical cultivations, the need to spray with dinoseb is eliminated and the increased susceptibility then becomes of no consequence. This approach of fitting the cultural techniques to the chemical is typical of the more successful work in this field.

In view of these divergent views and reports of differential varietal response to TCA there is obviously need for further evaluation of this compound.

There are, however, other compounds which merit further evaluation for oat control in peas, namely prophan and CDEC; both have given promising control of wild oat in trials without any evident crop damage. It seems certain that in the near future there will be a definite recommendation for peas.

Considering now the more difficult and extremely important control of wild oat in cereals.

Work attempting to sterilise the wild oat seeds in the growing crop with maleic hydrazide has had only indifferent success.

Some success with CDAA and CDEC for the control of wild oat in barley has been reported in the U.S. and by L. H. Shebeski in Canada. These compounds have also given a considerable measure of control in barley in this country. The degree of success of these compounds depends upon their high volatility, allowing a rapid diffusion through the soil, so ensuring contact with the wild oat and a fairly rapid breakdown in the soil, thus reducing the period of soil toxicity to the crop.

These properties enable a pre-sowing technique to be employed spraying the plough furrow and incorporating into the soil 10 to 14 days before sowing the barley.

The results using this method were on the whole promising; the variation and crop damage were no more than could be expected when evaluating new compounds and techniques.

The experimental work did show without doubt that CDAA and CDEC will kill wild oat if brought into contact with the seeds.

When considering the research reports presented in this field it is significant that the rates of application for any worthwhile control are in the 7.5-12 lb/ac region. The explanation seems to be that the chemicals we are considering are essentially grass seed inhibitors and hence enough of the chemical must be applied and incorporated into the soil to give a sufficient concentration to prevent germination. This is in contrast to the normal hormone herbicides of the MCPA type, which are applied to the growing plant and hence smaller quantities can be used.

Whilst a grass hormone herbicide, if one is ever developed, would control wild oats in broad-leaved crops, it is difficult to envisage a compound which could differentiate between say wild oats and cereals. It seems inevitable that to control wild oats in cereals some modification of cultural techniques is essential to enable the compound to attack the wild oat before the sowing of the cereal. This technique has been adopted in the present trials with CDAA and CDEC, and the fitting of the crop to the chemical is a general trend which will more and more come to the fore, with the growing need to control weeds in related crop species. We believe the problem of wild oats in cereals is sufficiently serious to merit such measures.

Dr. E. W. Debney

With reference to Mr. Dadd's remarks on the wild oat being classed as an injurious weed seed, statistics at the Official Seed Testing Station on the occurrence of weed seeds in seed tested for certification show wild oat occurs in just about twice as many samples as the next injurious weed Rumex. That is I think a little surprising. Last season over 9% of the barley samples we tested contained wild oats. I think that is perhaps a little frightening.

Dr. R. E. Slade

Could Miss Thurston tell me what percentage control of wild oats is needed in order to decrease the density of wild oats in that crop the following year? It would be useful for us to know this when we are hand weeding a corn or a root crop.

Miss J. M. Thurston

Unless this was the first year of the infestation, next year's seedlings would depend more on the seeds of the preceding 4 years than on this year. *A. fatua* as collected at harvest usually has 95-100% dormant seeds and in one field experiment more germinated in the second year than in the first year after sowing. One year's fallow (in which seeding is completely prevented) makes a scarcely noticeable reduction in the number of wild oat ears produced in the following year.

Dr. R. E. Slade

You might give me an idea whether it is 60% or 90%.

Miss J. M. Thurston

It rather depends on how big they grow. If it has to compete with 299 other wild oats in the same square yard you will get far fewer seeds produced by each plant than if only a few other wild oats are present.

Mr. C. V. Dadd

Surely the point Dr. Slade had in mind, the point I really wanted to emphasise at the end of my paper, is that we have consistently to allow fewer seeds to fall to the ground than we are able to kill seedlings annually on average. Quite clearly, as Miss Thurston pointed out, the number that are going to allow themselves to be killed every year by cultivation and other methods, will depend on a whole host of husbandry factors, weather and so on. Surely the short answer is that when you have a large number of wild oat seeds in your land you have to control a smaller proportion and as you get less, so it becomes more and more important to obtain complete control. That seems to me to be the simplication which I wish to get over to the farmers.

Dr. E. Åberg

The publication that Mr. Dadd referred to must be a paper on wild oat by Nilsson-Leissner. The data on the damaging effect of wild oat in cereals I believe are Danish.

I would like to stress the importance of cleanness of seeds and emphasise that although the Swedish regulations concerning seed certification are strict they are necessary. We should start with clean seeds and then remember the value of hand-rogueing as soon as wild oat plants appear in the fields. It is easier to hand-rogue when there are only occasional plants of wild oat than to kill the wild oat when it has become common. I consider the chemicals that can be used against wild oat only as complements to a good crop husbandry. As we have Avena fatua we find that cultivation against wild oat is best done during the spring. We get poor germination in the autumn and cannot reckon with good results from cultivation during that time of the year.

Mr. C. V. Dadd

Referring to Dr. Åberg's first point, the trials are indeed Danish. Since writing my paper I have heard from Professor Osvald who very kindly promised to obtain details of the references for our information. Professor Leissner was unfortunately unable to remember at the time the important Danish paper which gave specific information, Because the three references which I had are based on what we call advisory articles and rather hearsay, I do not think it appropriate to bring them to your attention.

The second point, hand-rogueing, I cannot agree more. I agree with Dr. Åberg when he says that it is the first two or three wild oat plants you see in a field that should be pulled. One should go and pull them up even if one is on the way to a wedding or to the pub.

I was very interested to hear about the inadequacy of autumn cultivations in Sweden. In this country comparing one autumn with another you will get very different results. Last autumn there is no doubt at all from observations in my part of the country that a very great deal can be done at that time of the year in encouraging wild oat seeds to germinate and then killing them.

Miss Thurston is, of course, quite right, the spring is always the more important time, one year with another it is just the time when one should stop and kill the germinated seedlings but it is just the time when farmers are in a hurry.

Mr. W. Van der Zweep

We found a tremendous difference in the action of CDEC in organic and clay soils but not with CDAA and therefore our results confirm your findings on the influence of soil moisture upon the action of CDAA. In addition I would suggest that the action of CDAA is strongly influenced by the organic matter content of the soil. I should like to know if you have obtained similar results.

Dr. R. D. Blackett

In the greenhouse studies on two types of soil I have not noticed any difference between CDAA and CDEC with temperature or soil moisture; this is quite different to what we found in the field. In America they maintain that CDEC is very much affected by rainfall, while CDAA is more effective under a range of soil moisture conditions and again CDAA tends to be more effective in soils of high moisture content. We believe that the organic matter of the soil helps to retain the compound within the soil in that climate, but the results of your findings and ours are rather conflicting in some respects and as yet I cannot say definitely one way or another.

If I may refer to Dr. Åberg I think that if you refer to Dr. Shebeski's work in Canada you will find CDAA used in conditions similar to those in Sweden. He applied the chemical in the autumn and found that by spring there was no residual toxicity in the soil with respect to barley and that a fair degree of wild oat control was obtained.