TABLE III. SUSCEPTIBILITY OF WEED SPECIES TO PRE-EMERGENCE APPLICATIONS OF MIXTURE OF ENDOTHAL AND PROPHAM.

Survivors as percentage of untreated. (treatments in lb/ac)

Site	Weed Sp.	Date of Assessment	No./ 1600 sq in.	Endothal + Propham 2 + 1½	4 + 3	6 + 4½
1	Stellaria media	24/4	261	50	19	
2	(Chickweed)	11/5	29		3	6
3		3/5	110	45	22	
4		4/5	95		10	3
6		5/5	17	30	0	
7		4/5	72		2	1
8		8/5	111		4	1
1	Polygonum	24/4	89	9	2	
2	convolvulus	11/5	21		0	0
3	(Black bindweed)	3/5	13	0	8	
6		5/5	13	0	0	
7		4/5	85		10	8
1	Veronica persica	24/4	71	1	4	
2	(Speed well)	11/5	18		0	0
5		5/5	39	0	0	
6		5/5	25	0	0	
8		8/5	225		0	0
1	Polygonum	24/4	67	6	0	
2	aviculare	11/5	20		10	5
5	(Knotgrass)	5/5	474		0	
6		5/5	49	0	0	
7		4/5	33		6	0
8		8/5	175		0	0
1	Sinapis arvensis (Charlock)	24/4	38	16	20	
1	Chenapodium album	24/4	16	94	88	
2	(Fat Hen)	11/5	14		100	66
5		5/5	71	43	4	
6		5/5	66	4	1	
7		4/5	55		85	18

TABLE III continued

Site	Weed Sp.	Date of Assessment	No./ 1600 sq in.	Endothal + Propham		
				2 + 1½	4 + 3	6 + 4½
2	Galium aparine (Cleavers)	11/5	22		14	5
3	Urtica urens (Annual nettle)	3/5	81	0	0	
4		4/5	113		0	0
3	Poa annua (Annual Meadow grass)	3/5	27	22	44	
5		5/5	14	0	0	
6		5/5	131	0	0	
7		4/5	10		0	0
3	Senecio vulgaris (Groundsel)	3/5	19	25	20	
7		4/5	10		20	40
5	Melandrium album (White Campion)	5/5	128	0	0	
5	Capsella bursapastoris (Shepherds Purse)	5/5	65	0	0	
5	Trifolium sp. (Clover)	5/5	24	0	0	
5	Fumaria officinalis (Fumitory)	5/5	18	0	0	
5	Matricaria maritima (Mayweed)	5/5	16	0	0	
7		4/5	31		9	0
6	Anagallis arvensis (Scarlet Pimpernel)	5/5	13	0	0	
8	Avena fatua (Wild oat)	8/5	53		50	20

PRE-EMERGENCE WEED CONTROL IN SUGAR BEET: EXPERIMENTS IN 1959 AND 1960

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Summary. In seven replicated trials in 1959 confirmation of earlier encouraging results was obtained with pre-emergence applications of endothal and mixtures of endothal and propham in sugar beet. Mixtures of cyclo-octyl dimethylurea (OMU) and butinol chlorophenyl carbamate (BIPC) appeared less reliable. The effectiveness of all treatments appeared to depend on the clay and organic matter contents of the soils, but the OMU/BIPC mixture seemed also to be affected by rainfall.

Tests on 28 sites in 1960 gave some confirmation of an influence of soil type on the action of endothal/propham but there was also a clear effect of rainfall after spraying. OMU/BIPC gave better results than in 1959 but some crop damage occurred.

Further work is required to study the effects of soil type and rainfall on the action of endothal/propham and OMU/BIPC and also on the effect of pre-sowing applications of endothal/propham.

INTRODUCTION

Experiments in 1958 on weed control in sugar beet with endothal and endothal/propham mixtures were described at the Fourth British Weed Control Conference (Murant, 1958). This paper presents the results of further experiments with these treatments and also with mixtures of cyclo-octyl dimethylurea (OMU) and butinol chlorophenyl carbamate (BIPC) which were tested successfully in Germany in 1958 (Hanf, 1959) under the code name HS/55.

METHODS AND MATERIALS

Experimental technique was the same as described previously (Murant, 1958). The chemicals used were as follows:-

Propham: 50 per cent w/w wettable powder (Bugges Insecticides Ltd.)

Endothal: 19.2 per cent w/v a.e. aqueous solution (Pennsalt Chemical Co., Washington, U.S.A.)

Endothal/propham mixture: in 1959 the above formulations were mixed and applied together; in 1960 a special formulation supplied by the Murphy Chemical Co. Ltd., Wheathampstead, was mostly used. This was a miscible oil containing 8.6 per cent w/v propham and 11.4 per cent w/v endothal a.e.

OMU/BIPC: miscible oil containing 8 per cent OMU and 5.5 per cent w/w BIPC (Boots Pure Drug Co. Ltd.)

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RESULTS

Experiments in 1959

In 1959 the chemicals were compared in seven replicated trials on a range of typical sugar beet soils, black fen being excluded because the chemicals were known to be inactivated on this soil type. Site details are given in Table I and results in Tables II and III. The herbicides were applied soon after sowing the crop in all trials except no. 3 at Ingham where the only weed of importance was wild oat; here OMU/BIPC was not used and the other chemicals were sprayed onto prepared land two days before sowing and harrowed into the soil. (The manufacturers of OMU/BIPC recommended it should always be applied after sowing, preferably within 3 days.)

Effect on Sugar Beet

Several treatments caused statistically significant reductions in braird at sites 1 - 4. These reductions assume practical significance when they are reflected in the final plant population. In Table II figures for percentage emergence are not given but it can be seen that 9 lb/ac endothal and the middle and upper doses of endothal/propham reduced the plant population in trials 1 and 3. Yield figures were obtained for trial 3 and show that this reduction in plant population led to a loss of yield of 7.8 cwt of sugar/ac, or 12 per cent of the crop. This was the only site where yield reductions were recorded; at Hemsby (trial 2) hoeing and singling of the plots was delayed and the sugar beet suffered considerable weed competition on the unsprayed plots, leading to significant increases in yield on all the treated plots.

Table II also confirms what has been noted previously, that, with sugar beet, considerable reductions in seedling size (vigour) may be produced by herbicides without affecting the yield.

Effect on weeds

Endothal was effective at all doses against *Polygonum aviculare*, *P. convolvulus*, *Stellaria media* (trial 1 only), *Matricaria maritima ssp. inodora*, *Senecio vulgaris*, *Anagallis arvensis*, *Capsella bursa-pastoris*, *Viola tricolor*, *Papaver rhoeas*, *Poa annua*, *Rumex crispus* and *Veronica persica*.

The endothal/propham mixture controlled all the above species well and gave improved control of *Stellaria media*, *Avena fatua* and possibly also of *Atriplex patula* (trial 1) and *Fumaria officinalis*. It is note-worthy that in trial 5 endothal/propham gave fair control of *Avena fatua* when not mixed into the soil.

Endothal and endothal/propham had little effect against *Atriplex patula* and *Chenopodium album* at any dose; the OMU/BIPC mixture gave better, although often still partial control of these species. Reduction in the number of other weeds with the OMU/BIPC mixture was of the same order as with endothal/propham for 8 species (including *Stellaria media*, *Senecio vulgaris* and *Poa annua*), but less for 8 other species (including *Polygonum aviculare* and *Avena fatua*).

Variation between sites

It was concluded as a result of the 1958 trials that there was no evidence that soil type influenced the action of these chemicals apart from their inactivation on black fen soil. However, it is clear from an inspection of Tables II and III that in 1959 the toxicity of all the herbicides, both to the crop and to the weeds, varied between sites and that they were most effective in trial 1 and least effective in trial 7. The trials have in fact been tabulated in order of decreasing crop and weed damage. Reference to Table I shows that there is a relationship between phytotoxicity and the amounts of organic matter and clay.

Information was also obtained on pH, free $CaCO_3$, and the N P_2O_5, and K_2O status of the soils but there is no obvious association of any of these factors with herbicidal activity.

If it is assumed that absorption onto soil colloids is important and that the absorptive properties of organic matter are 5 times that of clay (which may not necessarily be true for these herbicides) it is possible to calculate a figure for 'Relative Absorption' (= 5 x organic matter per cent + clay per cent) and the effect of this combined factor on the reduction in sugar beet vigour by the upper dose of endothal/propham is shown in Fig.1. Although adsorption onto soil colloids was almost certainly not the only cause of variation between sites, it appeared from this series of trials to be a major one, at least for endothal and endothal/propham. These latter treatments seemed to be relatively little affected by rainfall after spraying; for example the results at Sprowston in 1959 were not markedly different from those in 1958 described at the previous Conference (Murant, 1958), although the rainfall in the 28 days after spraying was 0.93 in. in 1959 compared with 2.77 in. in 1958. From some of the 1960 experiments and from tests carried out by the British Sugar Corporation the OMU/BIPC mixture appeared to be more dependent on rainfall than did the other treatments.

It was concluded as a result of the 1959 tests that although all the treatments were very dependent upon environmental conditions, endothal/propham was the most promising for future work, because it seemed likely to be affected mainly by soil type, a factor which could possibly be allowed for, as a result of further experiments, in selecting the dose to be applied. The dose of OMU/BIPC could probably not be chosen in the same way because of the rainfall effect. Endothal/propham was preferred to endothal alone because of the slightly broader range of weeds controlled.

Experiments in 1960

In 1960, endothal/propham was tested at four doses and OMU/BIPC at two, on 28 sites covering a wide range of soil types. Each dose was replicated twice at most sites. In all cases the chemicals were applied onto the soil surface soon after drilling.

Table IV gives relevant information for each site and Table V shows the effect of two doses of endothal/propham and one of OMU/BIPC on sugar beet and weeds. These doses were as follows:-

Endothal/propham A :- 6.75 lb endothal + 5.06 lb propham/ac

Endothal/propham C :- 3.00 lb endothal + 2.25 lb propham/ac

OMU/BIPC :- 0.50 lb OMU + 0.34 lb BIPC/ac

Effect on sugar beet

In Fig. 2 the figures for sugar beet vigour for endothal/propham dose A are plotted against those for "Relative Absorption" for comparison with Fig. 1, and in Fig. 3 against those for rainfall in the 21 days after spraying.

From these diagrams crop vigour appears to be positively correlated with "Relative Absorption" and negatively with rainfall.

The correlation coefficients are:-

Between crop vigour and "Relative Absorption" + 0.30 (barely significant at $P = 0.05$).

Between crop vigour and rainfall - 0.80 (significant at $P \leq 0.001$)

However, further inspection of Figs. 2 and 3, in which March applications have been distinguished from April ones, shows that:-

1) March applications were mostly on soils with low "Relative Absorption" figures. This is to be expected because light land is generally sown first.

2) More rain fell in the 21 days after spraying on sites sprayed in March than on those sprayed in April.

Thus there is a chance relationship between soil type, date of spraying, and rainfall following spraying and Figs. 2 and 3 are to some extent reflections of each other. Date of spraying could be important in so far as soil temperatures may affect the action of the chemicals but rainfall after spraying and soil type appear likely to have been of greatest importance.

The effect of these two factors has been examined independently by calculating the partial correlation coefficients. Thus the partial correlation coefficient between crop vigour and "Relative Absorption", eliminating the effect of rainfall from the analysis, becomes 0.15 (non-significant) whereas that between crop vigour and rainfall eliminating the effect of "Relative Absorption" becomes - 0.78 (significant at $P \leq 0.001$). Therefore in 1960 rainfall was apparently more important than soil type in determining the phytotoxic effect of endothal/propham.

Endothal/propham dose C and OMU/BIPC used at the dose recommended by the manufacturers both had similar effects on the crop; crop damage was generally low so that the effects of rainfall and soil type were less obvious than with the higher dose of endothal/propham, although they were similar.

Effect on weeds

No attempt was made in 1960 to score for control of individual weed species, so that some instances of poor weed control may be due to the predominance of resistant species. However, in general, weed control was good with dose A of endothal/propham and reasonably good with dose C except on sites with a high "Relative Absorption" figure and/or low rainfall after spraying.

The OMU/BIPC mixture was in most cases slightly inferior to dose C of endothal/propham.

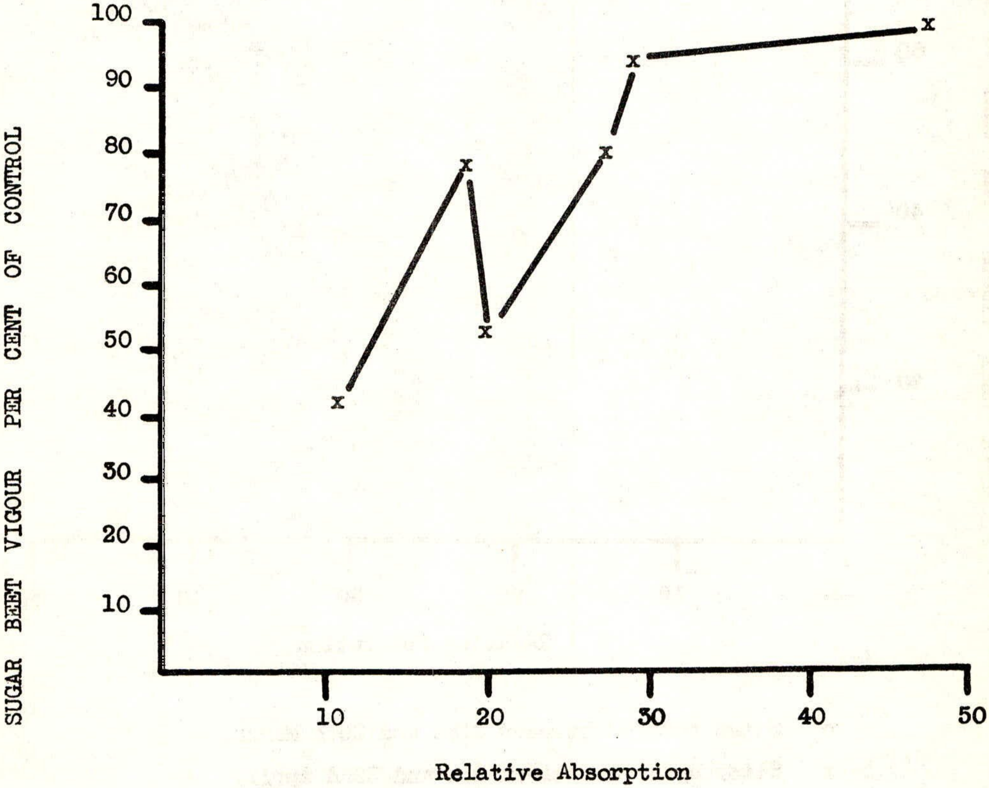
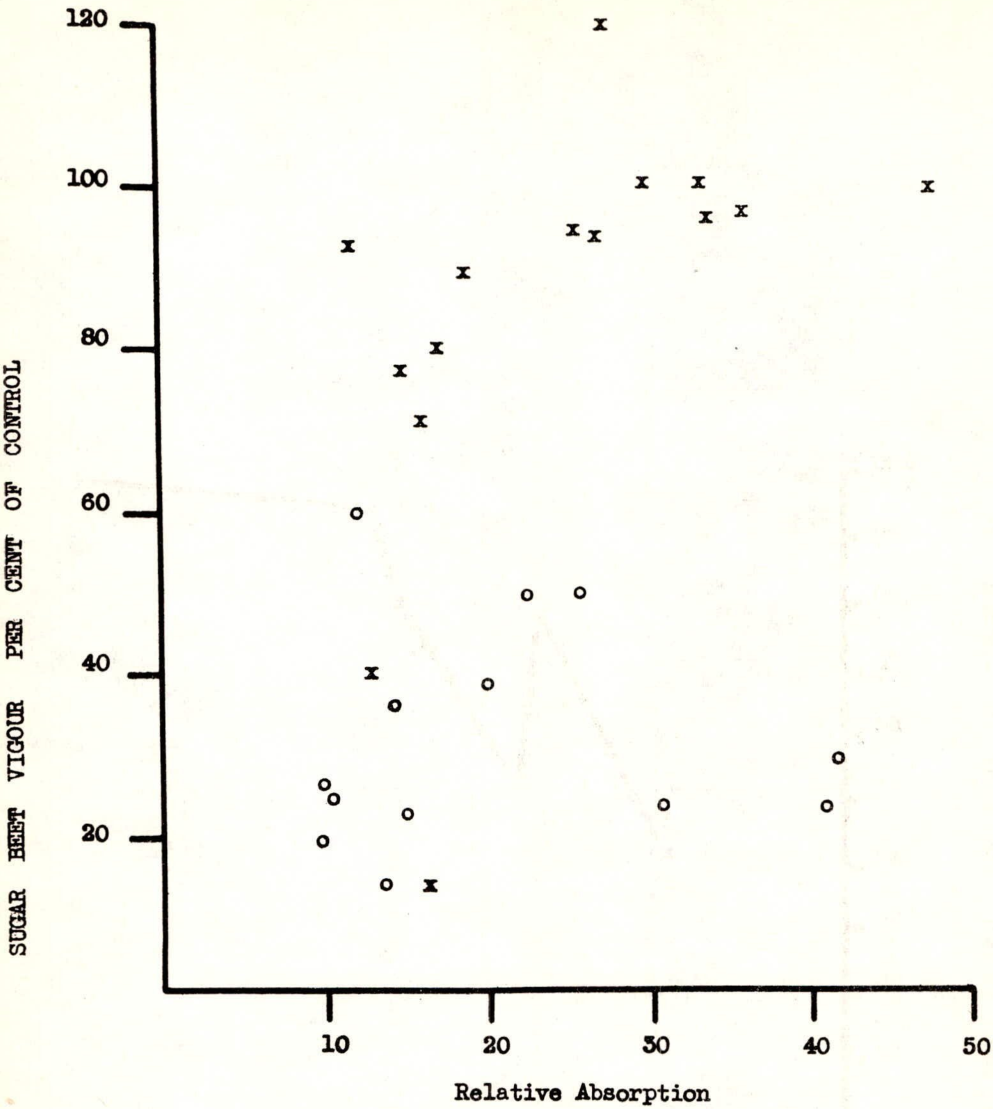


Fig. 1. The relationship between the Relative Absorption of the soil at each site and the effect on sugar beet vigour of 6 lb/ac endothal + 4.5 lb/ac propham (1959 experiments).



o Sites sprayed between 21st and 28th March.

x Sites sprayed between 4th and 22nd April.

Fig. 2. The relationship between the Relative Absorption of the soil at each site and the effect on sugar beet vigour of 6.75 lb/ac endothal + 5.06 lb/ac propham (1960 experiments).

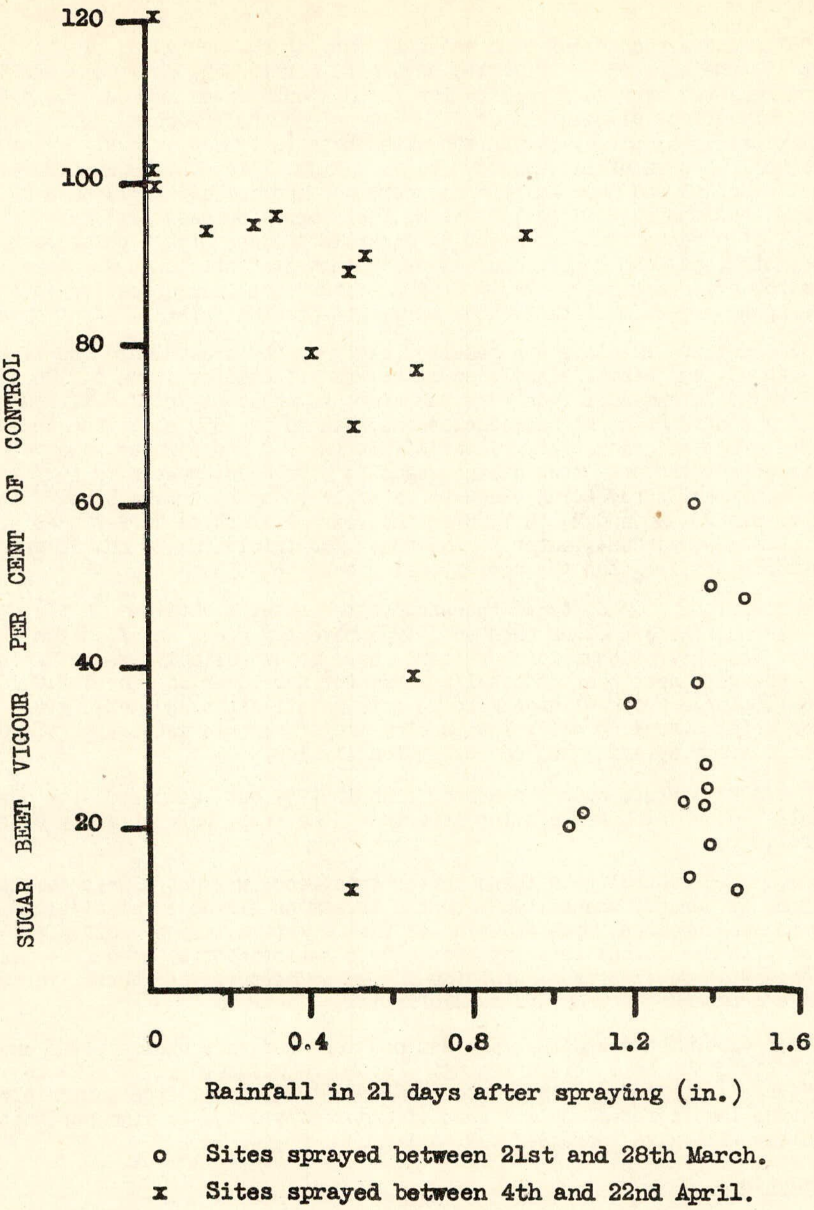


Fig. 3. The relationship between the rainfall in the 21 days after spraying at each site and the depression of sugar beet vigour by 6.75 lb/ac endothal + 5.06 lb/ac propham (1960 experiments).

Discussion

In 1959 seedbed conditions were generally dry at the beginning of the season but all the experiments reported here were carried out on middle and late sowings and received average precipitation in the month after sowing. No conclusions about the effect of rainfall on endothal or endothal/propham could be drawn from the 1959 trials except by comparison with those in 1958 previously reported (Murant, 1958), when rainfall amounts were very high. From this comparison it seemed that endothal and endothal/propham were not appreciably influenced by rainfall and that the main factor affecting their behaviour was soil type. Furthermore, it appeared that it might be possible to determine a relationship between phytotoxicity and some measurable soil characteristic such as clay content and/or organic matter. The OMU/BIPC mixture was less effective than endothal/propham and seemed likely to be more affected by rainfall after spraying.

In 1960 adequate rainfall was received early in the season when the lighter land was sown but the heavier land sown later was affected by drought. The effects of rainfall and soil type were therefore somewhat confused. Although there is some confirmation of the conclusions reached in 1959 about the influence of soil type, rainfall had a far greater effect in 1960 and appears to have been the more important factor. Crop damage seems to have been greater in 1960 than in 1959 on heavy soils receiving adequate rainfall (compare trials 6 and 7 in 1959 with trials 22, 26 and 27 in 1960). The reason for these differences are not clear but one important factor may be that 1960 trials 22, 26 and 27 were sprayed a month earlier than the corresponding ones in 1959.

It is clear that, in spite of the encouraging results obtained in the two previous seasons, factors other than soil type have too great an effect on the behaviour of endothal/propham for a suitable dose to be reliably predicted for any site. However, dose C of endothal/propham (or the lower dose D of 2.0 lb/ac endothal + 1.5 lb/ac propham) appear to be safe on all sites and would give fairly good weed control on soils low in clay and/or organic matter, provided that rainfall after spraying was not exceptionally low.

The OMU/BIPC mixture appeared better than in 1959 but, compared with dose C of endothal/propham which had similar effects on the crop, have slightly poorer weed control.

Although weed control with these latter treatments was not always complete there is some evidence (Murant, 1959) that a treatment giving a relatively small reduction in weed numbers, with stunting of the survivors, may be sufficient in combination with mechanical thinning, to leave a satisfactorily weed-free plant; the main object of developing a herbicide for sugar beet is, of course, for use as part of a programme of complete mechanisation.

In other experiments endothal/propham has appeared safe when applied and incorporated into the soil before sowing. Future work should be devoted to examining the effects and possible inter-relationships of soil type and rainfall on pre-sowing, incorporated applications of endothal/propham to find out whether this technique will give increased reliability.

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TABLE I. SITE DETAILS FOR 1959 SPRAYING TRIALS

Trial		Silt per cent	Clay per cent	O.M. per cent	Relative Absorption ⁂	Date drilled	Date sprayed +	Rainfall in 28 days after spraying (in.)	No. of days before rain
1	Docking, Norfolk	5	5	1.2	11.0	3/4	5/4	1.35	4
2	Hemsby, Norfolk	11	10	1.7	18.5	9/4	10/4; 19/4	2.26	4
3	Ingham, Norfolk	23	12	1.6	20.0	12/4	10/4	-	-
4	Sprowston, Norfolk	16	12	2.1	22.5	20/4	20/4; 21/4	0.93	3
5	Tannington, Suffolk	13	15	2.5	27.5	4/4	4/4; 9/4	1.51	1
6	Tacolneston, Norfolk	10	13	3.2	29.0	15/4	21/4	1.39	4
7	Swinefleet, Yorks.	26	27	4.1	47.5	23/4	23/4	1.30	3

⁂ See text

\+ Where two dates are given the first refers to the OMU/BIPC mixture only.

TABLE II. EFFECT OF HERBICIDES ON SUGAR BEET - 1959

(Treatments in lb/ac)

Assessment	Trial	Control	Endothal			Endothal + Propham			OMU + BIPC		S.E. per plot (per cent of mean)
			4	6	9	3 + 3	4.5 + 4.5	6 + 4.5	0.50 + 0.34	0.62 + 0.43	
Seedling Vigour, percent (Scores by two observers)	1	100	88**	84**	70**	88**	64**	65**	84**	66**	19.6
	2	100	99	95*	82**	80**	69**	49**	60**	64**	13.0
	3	100	-	69**	57**	53**	32**	36**	-	-	12.3
	4	100	98	93**	80**	92**	83**	82**	92**	82**	8.4
	5	100	102	90*	85**	82**	69**	75**	86**	72**	13.1
	6	100	98	96	98	95	84*	85*	88*	82*	19.5
	7	100	100	100	100	100	100	100	100	100	8.1
Final Plant Population (x 1,000/ac)	1	25.3	28.5	26.1	21.1*	24.7	17.6**	20.1*	25.1	22.1	13.9
	2	23.1	26.2	26.9	26.2	29.6	26.0	25.7	25.6	26.3	10.5
	3	27.5	-	26.6	24.8**	26.3	24.9**	24.0**	-	-	5.1
	4	28.9	29.0	28.8	28.0	29.4	28.4	28.6	28.6	29.3	4.2
	5	24.8	23.6	25.3	25.0	24.8	25.7	24.9	24.5	24.4	6.1
	6	17.6	18.4	16.8	18.7	18.8	17.6	21.5	17.9	17.8	12.4
	7	28.1	25.1	26.3	24.0	24.5	25.2	24.7	24.0	30.7	11.7
Sugar Yield (cwt/ac)	2	22.8	34.4**	34.0**	33.6**	33.2**	32.1**	32.0**	31.7**	33.0**	13.4
	3	63.7	-	65.2	59.3	61.1	57.9*	55.9*	-	-	6.9
	4	35.4	33.7	41.6	32.9	35.2	34.0	31.2	30.3	29.1	25.8
	5	58.3	56.0	59.9	59.6	57.7	55.4	55.4	56.9	55.2	5.6
	6	39.6	44.5	42.0	43.0	44.3	43.0	47.6	42.1	43.0	13.7

Asterisks indicate treatments showing significant differences from control at

* P = 0.05

** P = 0.01

TABLE III. EFFECT OF HERBICIDES ON PERCENTAGE SURVIVAL OF VARIOUS WEED SPECIES - 1959

Weed Species	(Treatments in lb/ac)							
	Endothal			Endothal + Propham			OMU + BIPC	
	4	6	9	3 + 33	4.5 + 4.5	6 + 4.5	0.50 + 0.34	0.62 + 0.43
TRIAL 1								
<u>Polygonum aviculare</u>	0	1	0	6	1	1	39	34
<u>Stellaria media</u>	9	4	2	0	0	2	15	2
<u>Atriplex patula</u>	82	71	35	35	47	47	35	0
<u>Chenopodium album</u>	60	37	16	72	38	22	22	26
Other weeds	1	0	1	1	2	2	30	28
TRIAL 2								
<u>Polygonum aviculare</u>	10	8	2	3	1	0	11	4
<u>Atriplex patula</u>	113	126	90	158	187	123	71	36
<u>Matricaria maritima ssp. inodora</u>	4	0	0	0	0	4	4	0
<u>Senecio vulgaris</u>	0	4	0	15	4	8	4	12
Other weeds	35	19	16	21	15	6	25	24
TRIAL 3								
<u>Polygonum aviculare</u>	-	15	8	9	4	2	-	-
<u>Avena fatua</u>	-	60	43	21	13	8	-	-
Other weeds	-	34	16	16	8	10	-	-
TRIAL 4								
<u>Polygonum aviculare</u>	20	7	7	7	0	0	7	33
<u>Stellaria media</u>	39	36	50	0	4	0	4	0
<u>Matricaria maritima ssp. inodora</u>	0	0	0	0	0	0	20	7
<u>Anagallis arvensis</u>	5	1	0	15	2	4	91	58
<u>Capsella bursa-pastoris</u>	9	4	0	26	4	0	9	0
<u>Fumaria officinalis</u>	54	92	19	173	38	4	85	100
<u>Viola tricolor</u>	9	3	6	25	12	3	22	16

TABLE III (Continued)

Weed Species	(Treatments in lb/ac)							
	Endothal			Endothal + Propham			OMU + BIPC	
	4	6	9	3 + 3	4.5 + 4.5	6 + 4.5	0.50 + 0.34	0.62 + 0.43
TRIAL 4 (Continued)								
Papaver rhoeas	0	0	0	0	0	0	0	0
Poa annua	12	7	2	1	0	0	4	1
TRIAL 5								
Chenopodium album	91	45	41	27	27	64	54	14
Avena fatua	80	82	74	34	27	29	101	106
Other weeds	82	59	56	31	35	28	45	49
TRIAL 6								
Polygonum convolvulus	39	30	23	36	23	11	39	54
Stellaria media	98	57	63	20	33	16	26	8
Rumex crispus	24	12	9	13	14	6	37	26
Veronica persica	22	18	10	13	29	13	68	49
Other weeds	53	46	27	50	42	37	67	68
TRIAL 7								
Polygonum aviculare	36	52	27	23	32	29	54	82
Sonchus asper	38	45	23	40	30	37	74	82
Other weeds	70	103	126	86	43	44	134	117

TABLE IV. SITE DETAILS FOR 1960 SPRAYING TRIALS

Trial			Silt per cent	Clay per cent	O.M. per cent	Relative Absorption*	Date drilled	Date sprayed	Rainfall in 21 days after spraying (in.)	No. of days before rain
1	Roughton	Norfolk	8.2	2.0	1.6	10.0	24th March	24th March	1.36	1
2	Aylsham	"	6.2	2.0	1.6	10.0	24th March	24th March	1.36	1
3	Trimingham	"	6.2	2.0	1.7	10.5	25th March	25th March	1.36	1
4	Plumstead	"	4.1	2.1	2.0	12.1	21st April	22nd April	0.50	3
5	Gimingham	"	6.2	4.1	1.7	12.6	25th March	25th March	1.32	0
6	Bircham	"	8.0	8.1	1.0	13.1	1st April	4th April	0.63	1
7	Garboldisham	"	6.0	8.1	1.2	14.1	22nd March	22nd March	1.44	5
8	Martham	"	4.1	4.1	2.1	14.6	25th March	28th March	1.15	0
9	Docking	"	4.0	6.1	1.8	15.1	1st April	4th April	0.63	1
10	Hockham	"	8.1	6.1	1.8	15.1	19th March	22nd March	1.03	9
11	Sth. Creake (i)	"	8.1	12.1	0.9	16.6	5th April	5th April	0.48	2
12	Brancaster	"	2.1	10.1	1.4	17.1	5th April	5th April	0.48	2
13	Trimley	Suffolk	22.3	10.2	1.5	17.7	6th April	8th April	0.37	1
14	Sth. Creake (ii)	Norfolk	8.1	12.2	1.4	19.2	4th April	5th April	0.48	2
15	Brumstead	"	18.2	12.1	1.7	20.6	24th March	25th March	1.32	1
16	Kenninghall	"	10.2	12.3	2.1	22.8	22nd March	22nd March	1.44	5
17	Brantham	Essex	12.3	14.3	2.4	26.3	7th April	8th April	0.13	5
18	Easton	Suffolk	8.2	16.4	2.0	26.4	21st March	21st March	1.38	6
19	Bunwell	Norfolk	12.2	18.4	1.8	27.4	6th April	7th April	0.91	0
20	Baston (i)	Northants	14.4	10.3	3.5	27.8	4th April	6th April	Nil	36
21	Baston (ii)	"	18.5	14.4	3.2	30.4	4th April	6th April	Nil	36
22	Boxford	Suffolk	26.8	16.4	3.0	31.4	18th March	21st March	1.32	8
23	Werrington	Peterboro'	14.3	20.6	2.6	33.6	1st April	6th April	Nil	36
24	Eye	Suffolk	24.9	12.4	4.4	34.4	6th April	8th April	0.25	2
25	Rushbrooke	"	14.5	26.8	1.9	36.3	6th April	7th April	0.29	0
26	Halesworth	"	10.4	26.8	2.9	41.3	18th March	21st March	1.05	9
27	Attleborough	Norfolk	18.4	20.3	4.3	41.8	18th March	22nd March	1.39	6
28	St. Ives	Hunts	23.3	18.9	5.9	48.4	11th April	12th April	-	-

* See text

N.B. Rainfall figures were recorded as close to the trial site as possible but in a few cases the nearest rain gauge was up to 3 miles away.

TABLE V. EFFECT OF HERBICIDES ON SUGAR BEET AND WEEDS - 1960

Trial	Sugar Beet						Weeds		
	Emergence, per cent of control (counts on twelve 18in. x 4in. quadrats/plot)			Vigour, per cent of control (scores by two observers)			Cover, per cent of control (scores by two observers)		
	Endothal + Propham		OMU + BIPC	Endothal + Propham		OMU + BIPC	Endothal + Propham		OMU + BIPC
	Dose A	Dose C		Dose A	Dose C		Dose A	Dose C	
1	57	94	105	18	52	63	0	27	15
2	27	74	92	25	71	88	2	22	40
3	49	99	99	24	64	59	0	14	20
4	98	104	98	92	92	98	40	51	74
5	66	84	96	60	81	78	-	-	-
6	46	84	110	40	70	75	8	16	30
7	78	82	98	12	22	75	5	15	32
8	69	96	99	35	68	71	0	6	27
9	97	83	-	78	87	-	18	37	-
10	35	66	-	21	51	-	5	20	-
11	76	94	112	71	86	91	15	33	85
12	12	28	26	12	22	40	18	25	28
13	96	89	92	80	96	87	22	40	15
14	81	73	117	89	89	100	14	24	32
15	103	102	95	38	81	73	0	13	21
16	66	86	112	49	74	77	15	26	44
17	100	86	88	95	93	91	54	61	65
18	97	120	110	50	86	76	4	17	48
19	69	69	58	94	97	86	27	34	37
20	104	101	107	120	100	133	33	78	44
21	102	106	107	100	100	100	30	70	90
22	34	79	93	23	65	78	0	24	24
23	98	98	94	100	100	100	100	100	100
24	98	106	113	96	101	97	50	63	75
25	93	96	96	96	96	91	36	57	70
26	38	60	84	22	67	86	12	39	34
27	47	78	88	28	77	74	-	-	-
28	107	85	108	100	100	100	-	-	-

POST-EMERGENCE NITRATE OF SODA SPRAYS FOR COMBINED NITROGENOUS FERTILIZATION AND WEED CONTROL IN SUGAR BEET

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Summary. Effective weed control is obtainable in sugar beet fields by post-emergence spraying with 2½-3 cwt. nitrate of soda in 65-100 gal. water plus spreader/ac. The spray is most effective if applied when the beets have not more than two true leaves and the weeds are not beyond the cotyledon or small-rosette stage, and if preceded by good growing weather and followed by at least 24 hours' dry warm weather. Sixty per cent or more control is obtainable and the destruction and checking of weed growth make possible a saving of labour in hoeing and the postponement of hoeing and singling. There is no financial risk in the use of the spray because it acts as a nitrogenous fertilizer, giving a yield equal to that obtained with a solid top-dressing. The amount of nitrogen the spray contains should be taken into consideration in determining the nitrogen fertilization of the crop.

INTRODUCTION

A number of papers have been published recently in Britain, Eire and on the Continent on the use of nitrate of soda as a post-emergence herbicidal spray for sugar beet fields and it is the object of this paper to review the results of the trials described in these papers.

The apparent paradox of the use of a nitrogenous fertilizer as a herbicide is explained by the fact that the sodium in the nitrate of soda is beneficial to sugar beet, but is injurious to most annual weeds when applied as a solution to their leaves and can kill them or at least severely check their growth.

Lüdecke and Winner (1958) found that the susceptibility of plants to nitrate of soda spray is related to their threshold of plasmolysis. The higher the concentration of salt required to induce plasmolysis the greater is the resistance of the plant to the spray. For example, more than 50 per cent of the epidermal cells of leaves of *Polygonum persicaria* (redshank), a susceptible weed, were plasmolysed by the application of 0.3 mol $NaNO_3$ solution whereas sugar beet was unaffected by solutions of up to 0.5 mol.

Herbicidal sprays for sugar beet fields are of importance partly because of the extension of precision sowing with reduced quantities of monogerm seed, a practice which makes the crop more susceptible to weed growth (Detroux, L. *et al* 1959a, Parker, C. 1956) and partly because they save labour in hoeing (Joyce, J. 1958, Murant, A.F. 1959, Schaeffler, H. *et al* 1957).

METHODS AND MATERIALS

The materials used are nitrate of soda, water and a spreader. The addition of a spreader to the solution does not increase the susceptibility of resistant species but it does increase the injurious effect of the spray on susceptible species (Schaeffler, H. et al 1957). Spreaders which have been used successfully are Agral 90 at 2½ pt per 100 gal solution, Shellestol at ½ gal/100 gal and BASF Rapid-Netzer Special at 0.5 per cent.

Nitrate of soda is highly soluble in water and no difficulty is experienced in making up the spray provided that the material is added slowly to the water and the water is thoroughly agitated meanwhile (Parker C. 1955).

For the application of the spray a high-volume sprayer is required. The Belgian Institute for the Improvement of the Beet, Tirlemont, use a 2½-metre sprayline fitted with five nozzles (Detroux, L. et al 1959a). In Eire a special 4-nozzle boom has been designed for use with a high-volume sprayer (Joyce, J. 1958). The spray is generally applied to the whole field but band spraying is practised in Eire (4 in. bands) and has been successfully tested at Tirlemont (4 in. bands) and at the Göttingen Sugar Beet Research Institute (6 in. bands)(Detroux, L. et al 1959b, Joyce, J. 1958, Lüdecke, H. et al 1958).

The rates at which nitrate of soda overall sprays have been applied range from 1½ cwt in 50 gal (Malmus, N. 1959) to 3 cwt in 100 gal (British Weed Control Council 1958, Murant, A.F. 1959, Parker C. 1956). Those which have given the best results are 2½-3 cwt in 65-100 gal/ac (320-380 kg in 800 - 1,135 l/ha). Rates for band spraying vary greatly, e.g. 70 lb in 18 gal/ac (80 kg in 200 l/ha) for 4 in. bands in Belgium (Detroux, L. et al 1959b), 2 cwt in 80 gal/ac for 4 in. bands in Eire (Joyce, J. 1958) and 1¾ cwt in 50 gal/ac (230 kg in 600 l/ha) for 6 in. bands in Germany (Lüdecke, H. et al 1958).

Most investigators spray within 2 weeks of the emergence of the beet crop or when the beets have two true leaves. The best results are obtained when the spray is applied just after weed emergence or when the weeds are not beyond the cotyledon or small-rosette stage (Joyce, J. 1958, Lüdecke, H et al 1958, Murant, A.F. 1959); and after the dew has evaporated in the morning and before it begins to form again in mid-afternoon.

It has been found at Sprowston that spraying is most effective if preceded by rapid growing conditions so that the leaf tissues are soft and susceptible (Murant, A.F. 1959), and followed by at least 24 hours of warm, dry sunny weather (Parker, C. 1956). In Germany susceptible weeds have been observed, to show symptoms of injury 2 hours after spraying in warm, sunny weather (Schaeffler, H. et al 1957).

RESULTS

Effect on weeds

In Belgium 64 per cent and 45 per cent weed control was obtained with 2½ cwt nitrate of soda in 65 gal water plus spreader in 1958 and 1959 respectively (Detroux, L. et al 1959 a and b). In Bavaria 40 per cent control was obtained with 2 cwt in 50 gal plus spreader at Innerhienthal and 59-62 per cent with 3 1/8 cwt in 88 gal with or without spreader at Puch (Malmus, N. 1959, Schaeffler, H. et al 1957). At Göttingen the percentage weed control was 89-90 with 1¾ cwt in 65 gal and with 2½ cwt in 70 gal, plus spreader in both cases (Lüdecke, H. et al 1958). At Sprowston 53 per cent, 70 per cent and 80 per cent control was obtained with 2, 2½ and 4 cwt respectively in 100 gal water plus spreader (Norfolk.Agric.Station 1955). Thus, apart from one case in Belgium where the figure was only 45 per cent, 60-90 per cent weed control was obtained with 2½-3 cwt in 65-100 gal/ac (320-380 kg in 800-1,135 l/ha) in all trials for which adequate data are available.

According to Lüdecke and Winner (1958) it is not necessary that a selective herbicide should destroy virtually 100 per cent of the weeds; the success of the operation is ensured if only 60-80 per cent are killed or severely injured provided that these include the species which render hoeing difficult. They point out that it is precisely the species which have broad leaves and which cover the beets rapidly, which are largely destroyed by nitrate of soda spray.

Weed species have been classified according to their susceptibility to nitrate of soda spraying by Parker (1955), Schaeffler and Schmid (1957), British Weed Control Council (1958), Lüdecke and Winner (1958) and table 1 presents their conclusions.

Weeds in the susceptible class are either completely or almost completely killed or severely injured; those in the moderately susceptible and moderately resistant classes are more or less severely injured and impeded in development and those in the resistant class are either slightly injured or undamaged. Of the 49 species of weeds listed in the table, 32 are susceptible or moderately susceptible, only 11 are moderately resistant or resistant and 6 are variable.

All authors are agreed that weeds are mostly much less susceptible after the 2- or 3-leaf stage or when over 3 in. high. According to the British Weed Control Handbook (1958) weeds which are susceptible at the "seedling" (i.e. cotyledon to 2- or 3-leaf stage) are only moderately susceptible or moderately resistant at the "young-plant" (3- or 4-leaf to early flower-bud) stage and those which are moderately susceptible or moderately resistant at the seedling stage are resistant at the young-plant stage. There are some exceptions, however; Stellaria media and Veronica spp., for example, can be successfully controlled after the juvenile stage (Schaeffler, H. et al 1957).

The susceptibility of some species to nitrate of soda sprays has been found to depend on environmental conditions. Polygonum spp., Thlaspi arvensis and Veronica spp. are reported to be very susceptible under fairly moist conditions in Bavaria but only moderately susceptible under drier conditions, owing to denser hair growth interfering with the wetting of the leaves with the spray (Schaeffler, H. et al 1957).

An important aspect of the effect of nitrate of soda sprays which has been widely observed is the distinct retardation of the growth of the weeds (British Weed Control Council 1958, Lüdecke, H. et al 1958). Detroux and Wauthy (1959a) lay particular stress on this effect which they regard as the most important result of the treatment. They found that weeds which were not killed grew slowly and that those whose aerial parts were destroyed did not shoot again for six weeks. Norfolk Agricultural Station say that severe scorching and defoliation can be almost as useful as killing as it makes the beet more easily visible for hoeing and singling (Parker C. 1955). It is not necessary for the nitrate of soda spray to kill all weeds; if susceptible species are destroyed and species of intermediate reaction are temporarily suppressed this enables the beet crop to become established and to outgrow the weeds.

TABLE I. WEED SUSCEPTIBILITY TO NITRATE OF SODA SPRAYS APPLIED AT THE SEEDLING STAGE

	Susceptible	Moderately susceptible	Moderately resistant	Resistant
Alchemilla arvensis	—			
Anagallis arvensis	—			
Anthemis arvensis		—		
Anthemis cotula		—		
Atriplex hastatum				—
Atriplex patula				—
Capsella bursa-pastoris	—	—		
Chenopodium album			—	—
Cirsium arvense			—	
Convolvulus arvensis	—			
Equisetum arvense				—
Euphorbia helioscopia				—
Fumaria officinalis	—	—	—	—
Galeopsis ladanum	—			
Galeopsis tetrahit	—	—		
Galinsoga parviflora	—			
Galium aparine			—	—
Lamium amplexicaule	—	—		
Lamium purpureum		—		
Lycopsis arvensis		—	—	
Matricaria discoidea		—	—	
Matricaria maritima inodora	—	—		
Myosotis arvensis	—			
Papaver rhoeas	—	—	—	—
Plantago major			—	
Poa annua			—	
Polygonum aviculare	—	—		
Polygonum convolvulus	—	—		
Polygonum lapathifolium	—	—		
Polygonum persicaria	—	—		
Raphanus raphanistrum	—	—	—	
Senecio vulgaris	—	—		
Sinapis alba		—	—	
Sinapis arvensis	—	—		
Sonchus arvensis		—		
Sonchus asper		—		
Sonchus oleraceus		—		
Spergula arvensis	—	—		
Stachys palustris			—	
Stellaria media	—	—		
Taraxacum officinale			—	
Thlaspi arvense		—		
Tussilago farfara	—			
Urtica urens	—			
Veronica hederifolia	—	—		
Veronica persica	—	—		
Vicia cracca	—			
Viola arvensis	—			
Viola tricolor	—			

(78178)

Effects on labour

The percentage of labour saved by nitrate of soda spraying has been calculated in Germany. In Bavaria (Schaeffler, H. et al 1957) the saving amounted to 5-6 per cent. At Göttingen (Lüdecke, H. et al 1958) there was a saving of 11-15 per cent at 1½ cwt in 60 gal/ac and of 25 per cent at 2½ cwt in 70 gal.

The destruction and the retarded growth of weeds as a result of the use of herbicides make it possible to delay hoeing and singling and to carry out these operations with a smaller labour force. Hoeing and singling should however be carried out within a few days of spraying. (Detroux, L. et al 1959a, Murant A.F. 1959).

Effects on yields

Nitrate of soda sprays are a form of nitrogenous top-dressing and give yield increase equivalent to those obtained with solid top-dressings.

At Göttingen yields with nitrate of soda sprays were as good as or better than those obtained with equivalent solid top-dressings with nitrate of soda provided that the crop was thoroughly hoed. (Lüdecke, H. et al 1958). Root and sugar yield increases ranging up to 10 per cent and 5 per cent respectively as compared with the non-top-dressed control are reported (Detroux, L. et al 1959a, Malmus, N. 1959).

Other considerations

At Göttingen sugar yields were slightly reduced when the nitrogen contained in the nitrate of soda sprays (32 lb N/ac) was not taken into consideration in fixing the total nitrogen dressing for the crop (Lüdecke H. et al 1958). Parker (1956) says that when the basal dressing is reduced by the amount of nitrogen to be applied as top-dressing, in the form of spray, yields are unaffected by the spray. Trials at Sprowston (Murant, A.F. 1959) have established that nitrate of soda applied as a spray before singling is as effective as the equivalent quantity of nitrogen applied to the seedbed.

There is no greater financial risk in the use of nitrate of soda spray than in the application of the nitrogenous top-dressing in solid form. Should the weed control given by the spray be inadequate owing to unfavourable weather, faulty technique or some other factor, the spray still acts as top-dressing.

Nitrate of soda sprays are to be regarded as having two combined roles - nitrogenous top-dressing and post-emergence herbicide. Most workers emphasize that they should be used in conjunction with and not as a substitute for proper cultural operations.

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Presentation by Mr. C. Parker of preceding three papers on sugar beet

Mr. Dadd has already mentioned the necessity for a reliable herbicide treatment in sugar beet to supplement the various mechanical aids for quicker and easier singling of the crop with reduced hand labour. Quite intensive work has been in progress in this country for the last eight years but few truly selective herbicides have emerged. Against grass species (Avena fatua in particular) sodium trichloroacetate and propham have shown promise as selective herbicides.

Against broad-leaved weeds post-emergence nitrate of soda and sodium chloride have proved usefully selective and the paper by Coombe and Dundas provides a very useful review of the work done with nitrate of soda, indicating the way it should be used and the results to be expected. The drawbacks of nitrate of soda treatment are (i) the problem of handling large quantities of the chemical (2½-3 cwt/ac)(ii) the high volume of water required (100 gal/ac) when many farmers no longer retain a high volume sprayer. (iii) dissolving the material is time consuming (iv) for good results the treatment requires favourable weather conditions - preferably 24 hr dry post-application and finally (v) the important weeds Chenopodium album and Atriplex patula generally show some resistance to the treatment. In favour of nitrate of soda is its value as a nitrogenous fertiliser and references are quoted to work showing that it is of as much benefit to the crop applied as a herbicidal spray as it would be as a dry top-dressing or applied to the seed-bed, in terms of manurial value. It is certainly of great value in an emergency and could probably be used on a wider scale than at present. This paper is of value in reminding us of this well-established and somewhat neglected treatment. One aspect of nitrate of soda spraying not mentioned above is that the larger weeds may eventually recover from the scorch effect and necessitate hand-hoeing. Therefore the treatment is assisting rather than replacing hand-labour and there is great scope for a more thorough and reliable treatment.

Many pre-emergence treatments have been tested over the years and if a good one could be found it could have the advantage of removing weed competition from the start and in that respect be more ideal than a post-emergence treatment. Out of the many compounds tested, endothal and propham are the two which have proved truly selective, each against its own limited range of weeds. Murant first tried a combination of the two in 1958 and having obtained a useful widening of the weed spectrum, without any undue increase in toxicity to the crop, extended the work to seven experiments in 1959; these being reported in the first half of the paper by Murant and Cussans. Useful results were obtained with doses of 3 lb/ac of each, controlling most of the troublesome weeds other than Chenopodium or Atriplex. There was adequate rainfall at most of the sites reported upon and under these conditions there appeared to be some correlation of results with soil type. This led to considerations of how soils could be classified in relation to herbicidal activity and a factor known as "relative absorption" was suggested. Plotting herbicidal activity against this factor indicated some relationship-the greater the absorbing power the lower the activity.

In 1960 Cussans extended the work in an attempt to confirm the relationship of activity with soil type and laid down an extensive programme with 28 sites. In the meantime the Murphy Chemical Co. Ltd. had prepared a formulation incorporating both herbicides in a ratio of 4 parts endothal to

3 parts propham. This mixture was tested at 21 centres during 1960 as reported by Bagnall, Caldicott and Minter. The results from this series of trials indicated, in general, a tolerable relationship of herbicidal activity with relative absorption except at one centre where crop damage was greater than expected. Mr. Cussan's results were less satisfactory and there were three sites where appreciable crop damage occurred, following the application of a standard dose, in spite of a high relative absorption of the soils. The general conclusions therefore is that relative absorption is not a reliable criterion to use in fixing the dose of endothal/propham mixtures for weed control in sugar beet. There appears to be a risk of crop damage on certain heavier soils or under certain circumstances. Bagnall and his colleagues believe it may be due to high coarse-sand contents resulting in undue percolation of the prophem to the crop, while Cussans wonders if the anomalous results were associated with the long period of cold weather which followed these particular applications in mid-March.

Weed control varied considerably from site to site. In any one experiment there was always one selective dose but this dose was quite unpredictable. On some of the heavier soils the effective dose was unexpectedly low whilst in the absence of a reasonable rainfall, during seven to ten days after application, it was invariably high. This factor of rainfall was especially important this season and seriously affected the results reported in both papers. Hence it is still difficult to make reliable recommendations but, with the proviso that under dry conditions weed control may be disappointing, the following doses should be safe:

on light sands	2 lb endothal and 1½ lb propham/ac
on light/medium soils	3 lb endothal and 2½ lb propham/ac
on medium soils	4 lb endothal and 3 lb propham/ac (although there may be some element of risk of crop damage at this dose)

The treatment is definitely of value and should be useful but with endothal having high mammalian toxicity the search goes on for safer materials.

Results with a mixture of CMU and BIPC are reported by Cussans. The tests were not so intensive as with the endothal/propham mixtures and firm conclusions cannot be drawn. It is certainly of interest, having somewhat similar performance to endothal/propham under favourable conditions with, perhaps, superior control of <u>Chenopodium album</u>. This mixture is volatile and appears particularly subject to failure under warm dry conditions as may occur later in the season.

Either or both of these mixtures might be improved, so far as reliability of weed control is concerned, if they were incorporated shallowly into the soil. Bagnall and his colleagues have tested a simple V-shaped coverer-bar trailed immediately behind the spray. They believe that the results show some promise. With the aid of such a technique, or something similar, it is hoped that residual pre-emergence herbicide application in sugar beet might be made more reliable.

THE USE OF HERBICIDAL SPRAYS ON THE POTATO CROP

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Summary. The passage of tractor wheels over potato land can increase the number of clods and render more difficult the separation of tubers on a potato harvester. A technique has been evolved which reduces to a minimum the number of tractor operations. A fine tilth is produced before planting and inter-row cultivation eliminated by replacing mechanical with chemical methods of weed control. In three seasons of widely differing climatic conditions a mixture of dinoseb and TCA has given a uniformly high standard of weed control. With an early variety more rapid tuber formation and a slightly increased yeild have been obtained; with a late variety yields have remained unaffected. In all cases the clod content has been reduced. Tasting trials have failed to establish taint from the herbicide.

INTRODUCTION

A considerable amount of working is normally necessary on potato land in the early part of the season. This is associated with the production of a satisfactory tilth and with the control of weeds. Thus, during the growing season it is not uncommon to give upwards of ten passes of a variety of tractor drawn implements such as harrows, cultivators and drill ploughs. Whilst the use of these implements may reduce the clod size in the upper surface, observations have shown (N.I.A.E. 1958-59) that the passage of tractor wheels can produce consolidation of the soil and increase the number of clods, particularly in the sub-surface layer. Many of these clods are not subsequently broken down and render more difficult the ultimate separation of tubers in potato harvesters. In Britain, farming tradition has favoured inter-row tillage of the potato crop on the score of increased yield but there is no clear-cut evidence to support this practice. Indeed Pereira (1941) and Russell (1949) confirmed earlier American work when they found inter-row cultivation to depress slightly the yield of potatoes.

A reduction in the number of cultural operations would seem highly desirable and can be achieved simply by (a) producing the desired tilth before planting the crop and (b) the substitution of chemical for mechanical methods of weed control (Robertson 1960).

METHODS AND MATERIALS

In 1958, trial areas were cultivated with (a) disc harrows and rollers to give a uniform tilth similar to that normally accepted for potato land and (b) a rotary cultivator to produce finer clod sub-division. Furrows were opened at 28 in. row width, sets were planted and artificial fertilizer applied by hand after which the drills were split with front-mounted ploughs fitted with covering bodies. The land was then ridged to the final contour. The herbicides were applied by spraying when the first few leaves of the potato plants appeared above ground among the weed seedlings already covering the drill. The weeds were mainly *Polygonum persicaria* (redshank), *Polygonum* aviculare (knotgrass), Galeopsis tetrahit (hemp nettle) and Lolium italicum (Italian ryegrass) with some Chenopodium album (fat hen), Stellaria media (chickweed) and Agropyron repens (couch grass). The herbicides used were (i) dinoseb-ammonium salt and TCA-sodium salt at rates of 6 lb/ac and 10 lb/ac of active ingredient respectively and (ii) MCPA and TCA-sodium salt at 2¼ lb/ac and 10 lb/ac of active ingredient respectively. Dilution was such that the sprays were applied at about 40 gal/ac. A third series of plots in the randomised lay-out were left unsprayed. No further treatment of any kind was given after this stage. For comparison, plots were laid down which were not sprayed and received the mechanical cultivations normally carried out in the potato crop.

In 1959 and 1960 the dinoseb/TCA mixture was used at the same concentration and rate as previously. The land was prepared in a coarse and a fine tilth but the plots were much larger and a commercial planter was used to open the furrows, plant the tubers, apply fertilizer and cover, all in one operation. Drilling to the final contour was carried out immediately. Also in 1960 a smaller trial was laid down using diquat and TCA-sodium salt at rates of 2 lb/ac and 10 lb/ac respectively.

RESULTS

With the dinoseb/TCA mixture, weed seedlings were entirely eliminated and at harvest only occasional plants of couch grass were observed. These all emerged some time after spraying and stemmed from rhizomes covered deeply in the ridge. The potato varieties used were Kerr's Pink and Epicure and plants developed normally with perhaps a slight tendency in the former for the pink colouration in stem and mid-rib to be rather less obvious than usual. Tasting tests carried out on the tubers failed to disclose any residual effect.

The MCPA/TCA mixture used in 1958 gave good control of some of the weeds but others survived, especially Italian ryegrass and soon covered the drill. This treatment was discontinued in the subsequent trials. Diquat/TCA has given excellent control of all weeds in the present season although final results will not be available until the crop is harvested.

The crop yields in Kerr's Pink in 1959 were uniformly high. On the soil of normal tilth which received six inter-row cultivations the average yield was 13.0 ton/ac while on the same soil with herbicide and no inter-row cultivation it was 13.2 ton/ac. Where additional preliminary treatment had been given to produce a fine tilth the yields were 15.0 ton/ac and 15.1 ton/ac respectively for conventional inter-row cultivation and spray treatment. There was therefore, no evidence of a depression in yield following the use of the herbicide.

With the early variety Epicure grown in the 1960 trials inter-row cultivation, which amounted to nine tractor operations, retarded the rate of development when compared with the spray treatment. Although in the latter case, the plants did not appear through the ridge so early, they subsequently developed more rapidly. Size distribution analyses made throughout the growing season showed a consistently greater number of larger sized tubers in the sprayed plots. The final yields were 10.5 ton/ac and 11.9 ton/ac for normal and spray treatment respectively.

An analysis was made of the material discharged over the web of an elevator potato digger. In this way it was possible to obtain a reasonably accurate measure of the clods and tubers which have to be separated in a complete potato harvester. Results set out in table I represent mean values from five runs of the digger. Two main treatments are given for comparison (a) normal working before planting followed by inter-row cultivation and (b) rotary cultivation before planting followed by spray treatment only.

TABLE 1. CLODS AND TUBERS HARVESTED PER 100 FT OF RIDGE

Size Group	Inter-row Cultivation				Spray Treatment			
	Clods		Tubers		Clods		Tubers	
	Number	Wt(lb)	Number	Wt(lb)	Number	Wt(lb)	Number	Wt(lb)
Over 2¼ in	46	31	141	53	9	5	213	75
2¼ in - 1¾ in	72	23	272	55	23	6	261	53
1¾ in - 1¼ in	319	44	211	18	110	13	173	14
Total over 1¼ in	437	98	624	126	142	24	647	142

It is obvious that the number of clods was much reduced by producing initially a fine soil tilth and replacing chemical for mechanical methods of weed control. The ratio of clods to potatoes was approximately 2 to 3 with the conventional cultural methods and 2 to 9 with rotary cultivation and spraying, an alteration which must have a material effect on the ease of separation. There was also a more rapid development of tuber size in the sprayed plots. This would enable an economic yield to be obtained slightly earlier, a feature of some importance with an early variety such as Epicure.

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TRIALS OF CHEMICAL WEEDKILLERS IN POTATOES

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Summary. An account is given of herbicide trials in potatoes at Invergowrie in 1959 and 1960. Dinoseb-amine, applied at 6 lb/ac to the ridged drills shortly before the emergence of the crop, successfully replaced cultivations as a means of weed control and caused no reduction of crop yield in 1959. Yields for 1960 have still to be recorded. Simazine and other residual herbicides of low solubility gave poor results, probably because their application was followed by dry weather conditions: but some of the less insoluble triazines showed promise. The results largely confirmed North American experience. Preliminary tests on cooked tubers suggested that slight tainting might have been caused by certain of the treatments. Tubers from all treatments sprouted normally in the spring after harvest.

INTRODUCTION

Potatoes require intensive working for weed control until the haulm forms a continuous cover. In some soils cultivations may have beneficial effects in addition to the control of weeds (Hawkins, 1960; Aldrich & Campbell, 1952), although excessive cultivations can reduce yields (Aldrich et al., 1954) and probably retard maturity. Tractor operations on some soils, especially in wet conditions, produce clods which remain until lifting and increase hand work on mechanical harvesters (Robertson, 1960). Chemical weedkillers have successfully been used in North America, where several states issue recommendations (Aldrich et al., 1954; Trevett & Murphy, 1960). These are either for residual herbicides to be sprayed at planting time or for contact herbicides to be used just before the crop emerges. Diuron is recommended at 0.75 lb/ac but is ineffective unless rain falls within two weeks of spraying. Other substituted ureas and several triazines have been used, but all, like diuron, depend for success on rainfull soon after application (Bell & Tisdell, 1958). Dinoseb-amine at 3-6 lb/ac, applied just before the crop emerges, is used to destroy young seedlings of broad-leaved weeds which have grown since planting, and can be combined with either TCA or dalapon if annual grasses are present. Provided that the potato growth is normal, further weed growth is smothered by the crop. Much of the American work refers to "lay-by" weed control (Sawyer et al., 1960). This means control of weeds, mainly annual grasses, that germinate after the final cultivation - a problem that occurs in Britain only when volunteer plants of Italian Rye-grass germinate at this stage.

METHODS AND MATERIALS

Weed control work in potatoes at Mylnefield began in 1959 with a screening trial of a large range of materials and a replicated trial of three herbicide mixtures and simazine. The varieties grown were Home Guard, Majestic and Redskin, planted on 20 - 21 April. The herbicides were applied

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at the weights of active ingredient per acre shown below and each at a volume rate of 40 gal/ac. In the screening trial the treatments were:

Treatment	Application
1. fenuron 0.5 and 1.0 lb	Applied 17 days after planting, without renewed cultivation
2. monuron 1.0 lb	
3. atrazine 1.0, 2.0 and 3.0 lb	
4. EPTC 9.4 lb	
5. tris - (2, 4 - dichlorophenoxyethyl) phosphite*	
6. chlorpropham 2.4 lb	
7. trietazine 1.0, 2.0 and 3.0 lb	Applied to a re-cultivated, weed-free surface 36 days after planting.
8. propazine 1.0, 2.0 and 3.0 lb	
9. TCA 8 lb. + dinoseb-amine 6 lb	Applied 36 days after planting, without renewed cultivation.
10. dalapon 2.5 lb + dinoseb-amine 2.7 lb	
11. dinoseb-amine 2.7 lb	
12. dinoseb-amine 6 lb	
13. PCP 3.6. lb	
14. MCPB 2 lb	
15. mecoprop 1.88 lb	

The treatments in the replicated trial were:

Treatment	Application
1. 2,4-DES 3.6 lb + propham 4 lb	Applied 4 - 7 days after planting.
2. 2,4-DES 3.6 lb + fenuron 0.5 lb	
3. simazine 1.5 lb	
4. dalapon 5 lb + dinoseb-amine 6 lb	Applied 32 days after planting, without renewed cultivation.

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* as 379 ("Falone")

At the time of the earlier sprays no weeds had germinated, but a heavy growth of Fumaria officinalis, Chenopodium album, Lamium amplexicaule, Veronica persica, Polygonum aviculare and P. convolvulus was present when the later sprays were applied. The control plots, cultivated according to normal local practice, were kept clean until nearly the end of June, about 8 weeks after planting. They received nine post-planting cultivations, as follows:

planted	20.4.59	grubbed	24.5.59
harrowed	12.5.59	grubbed	5.6.59
grubbed	13.5.59	grubbed	16.6.59
ridged	14.5.59	grubbed	21.6.59 approx.
harrowed	23.5.59	ridged	21.6.59 approx.

The 1959 season was unusually dry, and the residual herbicides were applied to dry soil. Although 0.74 in. of rain fell soon after the simazine was applied to the main trial, only 0.62 in. fell during the following five weeks. The experimental area appeared from July onwards to be divided into areas of good growth and of relatively poor growth, but the explanation of these differences was not established.

The potatoes in the replicated trial were lifted and weighed. Chats were weighed separately at harvest and the clamped tubers were later graded into ware, seed and thirds. Tubers from all treatments were kept for sprouting tests in 1960.

Tuber samples from the replicated trial were sent to the Ministry of Agriculture, Fisheries and Food's Research Establishment at Aberdeen and to the British Food Manufacturing Industries Research Association at Leatherhead, Surrey, to be tested for chemical tainting. The tests at Aberdeen were on cooked samples from fresh and dehydrated material, and those at Leatherhead on potato crisps. The technique used at Aberdeen relied on a panel of tasters who attempted to pick out the odd sample from three, two of which were from potatoes not sprayed with herbicide. The chance of doing this by a simple guess is 1 in 3. At Leatherhead the method was similar, except that the tasting panel of 12 was selected from a larger group of 33 for ability to detect taint induced in potato crisps by soaking in dilute solutions of "T.C.P." proprietory antiseptic. In the tests for herbicide taint, each combination of herbicide and variety was tested at least twice. In most of the tests the crisps from treated and control plots of the same variety were fried together, because colour differences had been noted in earlier tests where samples had been cooked separately. Note was made of any differences in appearance following identical cooking.

In a further replicated trial on the variety Majestic in 1960, herbicide sprays were applied just before the potatoes emerged. The treatments were:

dinoseb-amine 6 lb (a.e) + dalapon 2.5 lb

trietazine 2 lb

atrazine 2 lb

hand-hoed control

mechanically cultivated control

A screening trial of various rates of dinoseb-amine, diuron, simazine, CMU/BIPC (as "H.S.55") and simazine + chlorporpham was also conducted.

RESULTS

Weed Control

(i) 1959 replicated trial

In this trial the three residual mixtures applied a few days after planting gave negligible weed control, probably because of the low rainfall already noted. There was a reduction in Chenopodium album on the fenuron/ 2,4-DES plots, but the plots of all the residual treatments were smothered with weeds by the beginning of June and the potato haulm growth was obviously depressed. The contact spray of dinoseb and dalapon, however, which was applied to a heavy cover of weeds as mentioned above, gave an almost complete kill, and very few seedlings developed later. These were quickly smothered by the haulm growth. In the poor areas of growth that have been mentioned, the potatoes competed less successfully with the weeds. Few weeds grew on the control plots after cultivations ceased in early June.

(ii) 1959 screening trial

Of the treatments applied 17 days after planting, atrazine at 2 lb and 3 lb gave good weed control despite the dry conditions, and caused no apparent damage to the potatoes. The other treatments gave negligible weed control.

Of the later treatments, propazine and trietazine applied at 2 lb and 3 lb after re-cultivation gave good weed control with little or no effect on the potato growth. Dinoseb-amine at 6 lb was also effective, but dinoseb at 2.7 lb and PCP at 3.6 lb were much poorer. The addition of TCA to the lower rate of dinoseb appeared to decrease the subsequent weed growth. Neither mecoprop nor MCPB gave adequate weed control, and both had a direct stunting effect on the potatoes. Following the use of either TCA or dalapon, tubers of the variety Redskin were less highly coloured than tubers from the control plots.

(iii) 1960 trials

The results in 1960 were similar to those of 1959. Dinoseb-amine at 6 lb with or without TCA or dalapon, again gave a good control of annual weeds which had germinated since the time of planting. None of the residual treatments gave adequate weed control, possibly because the soil was again dry at the time of spraying and rainfall was negligible for several weeks after spraying.

Yield of crop

Total yields from the 1959 replicated trial are given in Table I.

TABLE I. YIELDS OF POTATOES (ALL GRADES) IN 1959

Treatment	Majestic cwt/ac	Redskin cwt/ac	Home Guard cwt/ac
2,4-DES + propham	122.8	104.4	59.4
2,4-DES + fenuron	87.1	81.6	43.1
Simazine	90.4	74.7	53.3
dinoseb-amine + dalapon	183.3	150.4	85.5
Control	194.8	144.5	102.4
S.E. of the difference between any 2 chemical treatment means	17.9	12.9	9.4
S.E. of the difference between the control and any other means	17.3	15.9	15.4

Despite the large experimental errors, probably caused by the uneven growth in different parts of the field, analysis of the total yields showed clear results. The dinoseb/dalapon treatment caused no significant reduction in yield (compared with the control) in any variety, whereas each of the remaining treatments, in which weed control was very poor, significantly depressed yield.

Figures are not yet available for the 1960 replicated trial.

Taint tests and sprouting

Aberdeen tests. The proportion of tasters able to discriminate between controls and herbicide-treated potatoes was in most cases more than 1/3, but only in the case of simazine did a clear majority of the tasters detect the treated samples.

Leatherhead tests. The tasting panel at Leatherhead was asked to comment on the flavour of the crisps, in addition to trying to pick out the odd sample in each triangular test. They did successfully detect some samples from the sprayed plots, but not consistently either for variety or for treatment. The panel did not detect the simazine-sprayed sample of any variety more frequently than could have occurred by chance. On 14 occasions when the treated sample was correctly identified an adverse comment was passed on the flavour of the treated potatoes, but in 125 other correct identifications no preference was shown. In one case the flavour of a control sample was criticised. Colour differences occurred between the controls and the treated samples even after identical cooking, but there was no consistent connection between the presence of a colour difference and detection of taint by the panel.

Potatoes from all the treatments sprouted normally in spring 1960.

DISCUSSION

Dinoseb-amine gave as good a control of weeds in 1959 as normal cultivation, with no reduction in yield. The effects of cultivations on the potato crop, apart from the control of weeds, are little understood, but certainly vary from season to season. Too much, therefore, should not be read into this result. The spring of 1959 was unusually dry, which was perhaps the reason for the unreliability of all the residual herbicides except some of the triazines. Both the success of the dinoseb treatment and the variable results with residual herbicides were to be expected in view of published North American work.

No chemical method of weed control will be acceptable if unpleasant or dangerous residues reach the tubers. The tests conducted at Leatherhead and Aberdeen might suggest that weedkillers used at rates that give good weed control do not cause tainting which is easily recognizable. It is very important, however, that tests of this kind should regularly be included in herbicide work on crops for human consumption.

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THE USE OF SIMAZINE ON WINTER SOWN FIELD BEANS

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Summary. This paper describes the effects of applying simazine at rates of 2 lb, 1 lb, and 0.5 lb/ac to winter sown field beans (Vicia faba) during the 1959-1960 season. Fifteen experiments on different soil types were carried out. Ten were sprayed only pre-emergence in early winter; the remaining five compared winter pre-emergence treatments with spring post-emergence treatments. Soil moisture conditions over the whole of the spraying period were favourable for the action of simazine and control of annual graminaceous and broad-leaved species was excellent. Wild oats (Avena fatua) was more effectively controlled by winter than by spring treatments. The converse was true of most annual broad-leaved species. The best time for the effective control of blackgrass (Alopecurus myosuroides) was dependent on soil type. The probable reasons for these findings are discussed.

The experiments confirmed previous findings that damage to field beans may occur at rates of simanzine in excess of 1 lb/ac. In these experiments, more damage was observed from winter applications than from spring applications of 2 lb/ac of simazine. Damage was greater on light or chalky soils than on heavy soils. Where the infestation by blackgrass was heavy, significant yield increases accompanied its control by simazine. No yield increases were obtained on light gravelly sand where broad-leaved annuals were dense. On the contrary, on such soils significant yield decreases were recorded for the winter and spring treatments at the highest rate. In the absence of dense weed infestation, on heavy clay soils significant depressions only occured at the highest winter rate of application. No yield depressions occured on heavy soil sites heavily infested with wild oats, but increases obtained failed to reach significance.

INTRODUCTION

Following work reported by J.G. Elliot (1958a) which showed that field beans (Vicia faba) could be selectively sprayed and might prove resistant to simazine, a number of workers carried out trials during the following year on spring sown field beans.

The work carried out during 1959, the results of much of which were collected and tabulated by Elliot, led to the adoption of a tentative recommendation by the Recommendation Committee of the British Weed Control Council for the year 1960. The recommendation applied to spring applications of simazine to spring sown field beans. There was therefore a need to carry out some work on winter sown field beans to find out if it was possible to use simazine selectively under the very different climatic and soil moisture conditions prevailing during the winter.

Roberts (1958) has shown conclusively that in light soils simazine could reduce the stand and yield of *Vicia faba* at doses well below those considered safe on clay soils. Elliott (1958b) had found that field beans killed or damaged by simazine were often closer to the soil surface than those not damaged by the same rate of simazine. Gregory (1959) has since demonstrated that under moist soil conditions, bean damage increases inversely as the depth of sowing of bean seeds.

Finally, Hartley (1960) has suggested that in soils at or near full moisture capacity, such as would be encountered over the winter months, rainfall will be readily "accepted" by the soil aggregates and even leaching of the chemical will take place.

These considerations led to the conclusion that the winter application of simazine to field beans might be more hazardous than spring application. For this reason five replicated split plot experiments were laid down to compare winter and spring applications of equivalent rates of simazine.

Field beans are traditionally grown on the heavier soils and there are sound reasons for this practice. Because of the known differences of behaviour of simazine on different soil types, however, it was thought desirable to undertake work on as many soils as was practicable. Nine sites were chosen on typical heavy boulder clay soil, two on chalk marls, one on a Kimmeridge clay - skirt soil, one on loam, and one each on chalk and river gravel soils. No fen soil sites were used.

The preparation of winter seed beds on clay soils is normally extremely coarse Based upon experience obtained with coarse soil surfaces in the spring it is usually held that such conditions are unsatisfactory for the successful application of residual herbicides. In consequence fine seed beds are recommended. In the present studies, no attempt was made to alter in any way the soil surfaces as found on the fields chosen as experimental sites. Instead observations were made on the average size and frequency of the clay aggregate resting on the surface. These were also examined to determine their external and internal moisture condition.

The purposes of the experimental work carried out were as follows:-

1) to determine the effect on the crop of early winter applications of simazine, involving a relatively long period of exposure to subsequent rainfall,

2) to compare the winter applications of simazine with equivalent spring applications involving a shorter exposure to subsequent rainfall,

3) to record the effect of these winter and spring applications on the weed flora, with particular reference to blackgrass and to wild oats,

4) to ascertain the relative differences in response of crop and weeds to known quantities of simazine when applied to heavy, intermediate and light soils,

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(5) to observe any differences of effect which could be ascribed to surface soil texture.

METHODS AND MATERIALS

Two types of trial were laid down. The same doses of 2, 1 and ½ lb/ac simazine were used in each trial, and all were sprayed on the soil surface at a volume of approximately 20 gal/ac. The first series comprised five trials, each of eight randomised blocks of four main plots for doses and control. Main plots were divided into sub-plots for time. Plot size in these experiments was 28 sq yd. It was found possible only to determine dry bean yield on one experiment, the remaining four experiments being cut and weighed green.

The other series of trials, ten in number, were composed only of two replicates of four treatments, and included only winter applications. Plot size was 60 sq yd. Three of these trials were harvested green for yield data.

Winter applications were made between 4.11.1959 and 1.1.1960 as soon as practicable after the beans were sown. Spring applications made between 4.3.1960 and 18.3.1960.

Observations were made at the time of spraying of the condition of the soil as regards moisture content, with special reference to the soil surface and its texture as well as the moisture content of clay aggregates resting on the surface.

Observations were made at intervals throughout the year of the effects of treatments both on crop and weed. Weed counts were made during May and June of 1960. Two methods were used according to weed density or method of bean sowing. Where weeds were dense or bean rows too narrow or uneven, random quadrats were used. Where weeds were sparse and row width regular and wide, the method used was a count of seven (or fifteen) yards of randomly chosen alley between two rows. In this case figures were adjusted to a mean area on the basis of actual row width and length.

In trials harvested green, weights of bean plants, on an average sample of ten stems, were recorded as well as mean height of stem and number of pods.

RESULTS

Weeds

At four sites there were too few weeds to give useful information and at one site the crop and wild oats were too thick to allow counting without crop damage. Instead of counts at the latter site, weight of wild oats was recorded at harvest.

Wild oats occured on ten sites. When sprayed in the early winter 2 lb/ac simazine gave an average of 94 per cent kill of wild oats and the control ranged from 79 per cent to 100 per cent. Soil type appeared to have played little part at this dose. At doses of 1 lb and 0.5 lb, simazine was most effective on chalky soils and least effective on heavy clays. Spring applications of simazine were comparatively ineffective at the doses used. The results are shown in the tables on the next page.

TABLE I. PERCENTAGE REDUCTION OF WILD OATS

Winter spraying only

(i) Heavy soils (counts of wild oats)

Site	2 lb	1 lb	0.5 lb
T.21	79	46	72
T.22	95	33	-11
T.26	100	74	27
T.23	94	50	38
T.30	92	87	58
Mean	92	58	25

(ii) Heavy soils (weights)

Site	2 lb	1 lb	0.5lb
T.27	99	99	63

(iii) Chalky soils (counts)

Site	2 lb	1 lb	0.5 lb
T.29	99	96	83
T.31	98	90	72
T.35	88	72	51
Mean	95	86	69

(iv) Light loam (counts)

Site	2 lb	1 lb	0.5 lb
T.20	94	69	55

(78178)

TABLE I (Continued)

Winter versus Spring spraying

	Winter			Spring		
Site	2 lb	1 lb	0.5 lb	2 lb	1 lb	0.5 lb
T.20	94	69	55	53	7	41
T.21	79	46	12	28	-20	30
T.22	95	33	-11	-.23	40	-103
Mean	89	49	19	19	9	-11

Blackgrass was well controlled on heavy and chalky soils at all doses of simazine. The question of time of application of simazine appears to be important at least on some soils. Blackgrass occurred at only two sites where comparisons between winter and spring applications were made. The soils on the two sites were quite different, one being light loam and the other heavy boulder clay. On heavy clays and chalk marl soils, over 90 per cent of blackgrass control was obtained with a winter application of 0.5 lb/ac simazine. On the light loam site only 54 per cent control occurred with this application. Simazine applied at 0.5 lb/ac in spring gave only 31 per cent control on a heavy clay site, but gave 85 per cent control on the light loam site. These results are shown in the Table II.

TABLE II. PERCENTAGE REDUCTION OF BLACKGRASS

Winter spraying only

(i) Heavy soils and Chalk marl

Site	2 lb	1 lb	0.5 lb
T.22	100	99	95
T.30	100	99	92
T.35	100	100	99
Mean	100	99	95

(ii) Light loam

Site	2 lb	1 lb	0.5 lb
T.20	100	95	54