EXPERIMENTS WITH SOME HERBICIDE TANK-MIXES IN BULB ONIONS

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Summary In field experiments on a sandy loam in five successive years, addition of chlorthal-dimethyl at 3.0 - 6.7 kg a.i./ha to a standard pre-emergence application of propachlor at 4.37 kg a.i./ha gave improved weed control with no adverse effect on the yield of spring-sown bulb onions. Species relatively tolerant to propachlor and which were killed by the tank-mix included Polygonum aviculare, P. convolvulus, Viola arvensis, Chenopodium album, Lamium amplexicaule and Solanum nigrum. Good results were also obtained with a tank-mix of methazole 1.05 or 2.1 kg a.i./ha with ioxynil 0.35 kg a.i./ha applied at the 2- or 3-leaf stage of the crop. This gave broad-spectrum kill of weeds which had survived pre-emergence treatment with propachlor, and although there was some leaf scorch to an extent which depended on weather conditions, there was no significant loss of yield. The advantages and limitations of these two tank-mixes are briefly discussed.

INTRODUCTION

The initial experiments in UK with chlorthal-dimethyl as an additive to propachlor to improve the range of annual weeds killed and the duration of control were made on the overwintered bulb onion crop, drilled in August (Roberts et al., 1976). From 1974 onwards, chlorthal-dimethyl was included in experiments on the spring-sown crop, where there is a need for a pre-emergence treatment which is safe on light soils and which will control those weeds that are relatively tolerant to propachlor.

There is also a requirement to control weeds which for various reasons may escape the pre-emergence treatment or which may emerge later on when its activity has become attenuated. Although post-emergence herbicides are available for use on onions, and indeed have proved very valuable, none will deal effectively with the full range of weed species likely to be encountered. Tests were therefore made to evaluate combinations of herbicides. Methazole was selected because of the susceptibility of Polygonum spp. and ioxynil because of the known susceptibility of Matricaria and Tripleurospermum spp., which often cause problems in the onion crop, and of Fumaria officinalis. In this report the results obtained with tank-mixes of propachlor + chlorthal-dimethyl and of methazole + ioxynil are summarized and discussed.

METHODS AND MATERIALS

The soil was a sandy loam with approximately 2% o.m. The experiments were of randomized block design with three or four replicates. The plot size varied from 4 to 7 m^2, with four rows 30 cm apart of which the centre two were harvested. Seed of cv. Bola or Laco was drilled in March and the pre-emergence treatments applied about 3 weeks after drilling. Paraquat was added to all pre-emergence treatments to kill those weeds which had already emerged. The pre-emergence treatments were applied at a volume of 1100 l/ha, the post-emergence treatments at 450 l/ha. There were no unweeded controls, and a standard for comparison was provided by plots treated pre-emergence with propachlor which were then weeded by hand in late May or early June, before any competition had occurred, and kept clean thereafter. Counts of weeds surviving on each plot were made either then or somewhat later in June when the post-emergence treatments had taken effect; all plots were then weeded and kept clean until harvest. When the onion tops had died down, the bulbs were lifted, allowed to dry in the field and the total numbers and weights of sound bulbs per plot were recorded. In the Tables, these weights are given as percentages of that of the standard and significant reductions indicated by single (P = 0.05) or double (P = 0.01) asterisks.

RESULTS

Pre-emergence treatments

Comparisons of propachlor and propachlor + chlorthal-dimethyl were made in five successive years, while in 1974 and 1975 chlorthal-dimethyl alone was also included. Propachlor alone consistently performed well, reducing the naturally occurring weed population by about 90%. Species killed included *Veronica persica*, *Capsella bursa-pastoris*, *Senecio vulgaris*, *Matricaria recutita*, *Tripleurospermum maritimum* ssp. *inodorum*, *Urtica urens* and *Poa annua*. The surviving plants were of species which were virtually unaffected, such as *Fumaria officinalis*, *Polygonum aviculare*,

Table 1

Effects of propachlor and chlorthal-dimethyl applied pre-emergence

	Weeds/m^2 before weeding	Relative bulb yield
1974		
Propachlor 4.37	4.6	100
Chlorthal-dimethyl 12.0	18.6	96
Propachlor 4.37 + chlorthal-dimethyl 4.0	1.9	99
Propachlor 4.37 + chlorthal-dimethyl 6.0	1.2	100
1975		
Propachlor 4.37	6.6	100
Chlorthal-dimethyl 12.0	11.4	94
Propachlor 4.37 + chlorthal-dimethyl 6.0	5.0	101
1976		
Propachlor 4.37	3.0	100
Propachlor 4.37 + chlorthal-dimethyl 3.4	0.7	101
Propachlor 4.37 + chlorthal-dimethyl 6.7	0.5	105
1977		
Propachlor 4.37	26.1	100
Propachlor 4.37$^+$	1.5	91*
Propachlor 4.37 + chlorthal-dimethyl 3.0$^+$	1.1	101
Propachlor 4.37 + chlorthal-dimethyl 4.5$^+$	1.6	96
1978		
Propachlor 4.55	16.7	100
Propachlor 4.55$^+$	0.8	102
Propachlor 4.55 + chlorthal-dimethyl 4.5$^+$	0.8	102

$^+$With methazole 2.1 kg/ha at the 2½-leaf stage.

P. convolvulus and Viola arvensis, or of which there had been a partial kill, such as Chenopodium album, Solanum nigrum, Lamium amplexicaule and Stellaria media. Chlorthal-dimethyl applied alone was less effective than propachlor in overall weed kill (Table 1). Besides Fumaria officinalis, on which there was no effect, surviving weeds included Poa annua, Capsella bursa-pastoris and Senecio vulgaris.

A combination of propachlor and chlorthal-dimethyl consistently gave better control of weeds than either herbicide applied alone. Fumaria officinalis was not affected, and it was the presence of this species which accounted for the small difference between the tank-mix and propachlor alone in 1975 (Table 1). Thlaspi arvense, of which a few plants sometimes occurred, was also unaffected. Otherwise, propachlor and chlorthal-dimethyl were complementary to a high degree in respect of the weed species in these experiments.

In 1977 and 1978, pre-emergence treatment was followed by a post-emergence application of methazole. The weeds that had survived pre-emergence treatment with propachlor were the same as in the previous experiments, F. officinalis, C. album, V. arvensis, P. aviculare, P. convolvulus, S. nigrum, L. amplexicaule and S. media. Methazole was effective against all these except F. officinalis, so that when assessed in June, the surviving weeds were the same whether or not the plots had initially received chlorthal-dimethyl in addition to propachlor. There was no evidence of crop injury on any of the plots treated with chlorthal-dimethyl, and the yields of bulbs did not differ significantly from those of the plots which had received propachlor only (Table 1).

Post-emergence treatments

Tests were made in three successive years to determine whether a combination of methazole and ioxynil could be used to control a broader spectrum of weeds than that killed by either herbicide alone. All the plots received propachlor pre-emergence.

Table 2

Effect of post-emergence treatments in 1976

Treatment (kg a.i./ha)	Stage	Weeds/m^2 before weeding	Leaf scorch	Relative bulb yield
No post-emergence treatment		2.3	-	100
Methazole 2.1	2-leaf	0.2	slight	96
Ioxynil 0.7	3-leaf	1.5	slight-moderate	81
Methazole 1.05 + ioxynil 0.35	2-leaf	0.1	slight	93
Methazole 1.05 + ioxynil 0.35	3-leaf	0.1	slight-moderate	95

In 1976, the main weeds which survived pre-emergence treatment were Polygonum aviculare, Chenopodium album, Stellaria media and Fumaria officinalis. With methazole alone at the full rate (2.1 kg a.i./ha) at the 2-leaf stage, the only survivors were F. officinalis and isolated small P. aviculare. Ioxynil at the full rate (0.7 kg a.i./ha) applied at the 3-leaf stage killed F. officinalis, S. media and most C. album, but not P. aviculare, so that overall control was less good than with methazole (Table 2). A combined treatment of half rates gave an excellent result, and only isolated very small plants of P. aviculare survived. All treatments caused some scorch of the onion leaf tips, slight at the 2-leaf stage but more pronounced at the 3-leaf stage. There were, however, no significant reductions in bulb yield compared with that of plots receiving no post-emergence herbicide.

Table 3

Effect of post-emergence treatments in 1977

Treatment (kg a.i./ha)	Stage	Weeds/m^2 before weeding	Leaf scorch	Relative bulb yield
No post-emergence treatment		26.1	-	100
Methazole 2.1	2-leaf	1.5	nil	91*
Methazole 1.05 + ioxynil 0.35	2-leaf	1.3	nil	101
Methazole 2.1 + ioxynil 0.35	3-4-leaf	0.1	moderate	92
Methazole 1.05 + ioxynil 0.70	3-4-leaf	0.1	severe	87**
Methazole 2.1 + ioxynil 0.70	3-4-leaf	0.1	severe	86**

Counts on an untreated area next to the 1977 experiment showed a weed density of 300/m^2. Propachlor killed more than 90% of these, with *Polygonum aviculare*, *Fumaria officinalis*, *Solanum nigrum* and *Stellaria media* the main survivors, although occasional plants of other species were also present. Where methazole alone was applied at the 2-leaf stage, *F. officinalis* was not affected but the only other survivors were a few plants of *P. aviculare*, *Chenopodium album* and *Tripleurospermum maritimum* ssp. *inodorum*. A combination of half rates of methazole and ioxynil applied at the same time killed all the dicots apart from one or two *F. officinalis* and the only other survivors were some small *Poa annua* on one of the three replicate plots. Neither of these treatments caused any visible leaf scorch or check in crop growth; the significantly lower yield with methazole alone (Table 3) reflected fortuitous variation in stand.

The three treatments applied at the 3-4-leaf stage all gave complete kill of *F. officinalis* in flower, *P. aviculare* up to 20 cm across, *P. convolvulus* 30 cm tall, *S. media* 30 cm across, *C. album* up to 10 cm tall and *S. nigrum* up to 5 cm. Other species killed included *Capsella bursa-pastoris*, *Atriplex patula*, *Lamium amplexicaule* in flower and *Thlaspi arvense* in pod. Most plants of *Poa annua* were killed; only isolated individuals survived, and these were severely checked. Most plants of *Matricaria matricarioides* and *Tripleurospermum maritimum* ssp. *inodorum* were also killed, although where only the half rate of ioxynil was applied the apical buds in one or two plants remained alive. These treatments were applied during a hot spell, and leaf scorch of the crop was greater than with the half rates at the 2-leaf stage. Even so, however, with only the half rate of ioxynil there was no significant yield loss (Table 3) and even with the full rate yield was reduced by no more than 14%.

Table 4

Effect of post-emergence treatments in 1978

Treatment (kg a.i./ha)	Stage	Weeds/m^2 before weeding	Leaf scorch	Relative bulb yield
No post emergence treatment		16.7	-	100
Methazole 2.1	2-leaf	0.8	slight	102
Methazole 1.05 + ioxynil 0.35	2-leaf	0.1	moderate	104
Methazole 1.05 + ioxynil 0.35	3-leaf	1.5	slight-moderate	100
Methazole 2.1 + ioxynil 0.35	3-leaf	0.9	slight-moderate	102

In 1978 the main weeds which survived pre-emergence treatment with propachlor were again *Polygonum aviculare*, *Fumaria officinalis*, *Solanum nigrum* and *Chenopodium album*, while occasional plants of *Stellaria media*, *Anagallis arvensis*, *Urtica urens*, Capsella bursa-pastoris and Lamium amplexicaule were also present. Methazole alone at the 2-leaf stage killed all these except F. officinalis while the tank-mix at this stage resulted in plots which were virtually clean. By the 3-leaf stage the weeds had become large, and although most were killed by both combinations, a few plants of P. aviculare and U. urens remained; they were, however, small and severely scorched. Although there was some scorch of the onion leaf tips with all treatments, by mid-July this had been outgrown and crop vigour was not affected.

DISCUSSION

In these experiments, pre-emergence application of a tank-mix of propachlor and chlorthal-dimethyl consistently gave improved control of annual weeds compared with propachlor alone (Table 1). The main advantage of adding chlorthal-dimethyl was control of species such as Polygonum aviculare, P. convolvulus and Viola arvensis on which propachlor has little effect and also of those such as Chenopodium album, Stellaria media and Lamium amplexicaule which are only moderately susceptible to propachlor. Chlorthal-dimethyl is also more persistent in the soil than propachlor (Roberts et al., 1978) and can give prolonged control of susceptible species, among them Solanum nigrum which may not begin to emerge until early May. In these experiments, good control of S. nigrum was obtained; potato seedlings from berries produced in previous years were also killed. Tests on a range of drilled vegetable crops at NVRS showed that red beet was among the most sensitive to chlorthal-dimethyl, so that control of weed beet may be a possibility where onions are grown in rotation with sugar beet.

As with autumn-sown onions (Roberts et al., 1976), the propachlor/chlorthal-dimethyl mixtures had no adverse effect on yield (Table 1). Onion appears to have a high degree of tolerance to chlorthal-dimethyl (Janůška, 1974), and there was no reduction in yield of a weed-free crop even where 12.0 kg/ha was applied (Table 1). Following work at NVRS, commercial development by Duphar-Midox Ltd. and Monsanto Ltd. has resulted in a tank-mix recommendation for mineral soils of 4.55 kg a.i./ha propachlor plus 4.5 kg a.i./ha chlorthal-dimethyl. It is possible that on light soils these rates might be reduced; in other experiments (Roberts et al., 1978) there was little difference between 2.9 and 4.4 kg/ha propachlor in initial weed kill when combined with chlorthal-dimethyl, while reducing the rate of chlorthal-dimethyl to 3.4 kg/ha had little effect on weed control. Toth et al. (1973) found that in New South Wales acceptable weed control for an adequate period was obtained with 2.6 kg a.i./ha propachlor plus 4.0 kg a.i./ha chlorthal-dimethyl.

In 1977 and 1978, the difference in weed kill between propachlor and the combined treatment was similar to that in previous years, but this difference was eliminated by application of methazole which killed all the species present except for Fumaria officinalis (Table 1). Nevertheless, the broader weed spectrum of the tank-mix and the persistence of activity against susceptible species conferred by chlorthal-dimethyl (Roberts et al., 1978) seem likely to be of practical value in many circumstances.

One outstanding limitation of the tank-mix is the tolerance of Fumaria officinalis, which is also unaffected by methazole. Moreover, the presence of chlorthal-dimethyl does not improve the control of Matricaria and Tripleurospermum spp. Where they are prevalent, plants may escape the pre-emergence propachlor or appear after its activity has become reduced and by the time that methazole can be applied may be too large for effective kill. It therefore appeared logical to examine mixtures of methazole and ioxynil, and the results were encouraging (Tables 2,3 and 4). In these and in previous experiments with onions, methazole has caused only slight damage to the leaf tips when applied at the full 2-leaf stage or later. Ioxynil, however, does appear likely to cause greater injury, especially if wax development on the onion leaves is poor or application takes place during a period of high temperature.

On the limited evidence of these experiments, the combination of half rates appears promising; Cassidy (1978) has also noted improved control of *Matricaria* spp. when ioxynil was added the methazole. Where the rate of ioxynil was 0.35 kg a.i./ha, any initial crop injury was overcome and there was no significant effect on yield (Tables 2, 3 and 4). The impression was gained that most of the injury was attributable to ioxynil and that the degree to which it occurred depended more on the prevailing conditions than on the stage of crop growth once the 2-leaf stage had been passed. The control of weeds with this combination of herbicides was very good, but more evidence is needed of safety to the crop before its value can be assessed.

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CHLORTHAL-DIMETHYL/PROPACHLOR - A TANK MIX FOR USE IN BRASSICAS, LEEKS AND DRY BULB ONIONS

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Summary The data presented illustrates the advantages to be derived by the addition of chlorthal-dimethyl to propachlor in a tank mix in terms of improvement in the spectrum of weed control without reduction in vigour of leaf and root brassicas and leeks or of yield and vigour of dry bulb onions.

INTRODUCTION

Vegetable growers are constantly striving for more reliability in weed control and because herbicides are no longer regarded as a partial substitute for hand weeding, there is no acceptable solution should herbicides fail. Propachlor, over the past decade has been widely used, but having limited residual activity and weak areas in its spectrum, a suitable complementary herbicide to apply with propachlor as a tank mix appeared beneficial. Trials at the National Vegetable Research Station (Roberts, private communication) indicated chlorthal-dimethyl to be a natural complement. Clearance of pesticides for tank mixing under the U.K. Government's Pesticides Safety Precautions Scheme is granted only for named products and not for active ingredients, hence the subsequent approval under the Agricultural Chemicals Approval Scheme is for the combined use of chlorthal-dimethyl as Dacthal® and propachlor as Ramrod® in tank mix for use on leaf and root brassicae, dry bulb onions and leeks. This paper describes trials undertaken by the respective manufacturers in the U.K. in which different mixtures were compared on a range of crop and soil types to determine crop tolerance and weed susceptibility. Site and trial details are shown in Table 1.

METHOD AND MATERIALS

a) Design

Trials B, H, J and N were applied logarithmically, other lettered trials were of randomised block design with three replicates. Trials contained untreated controls and an Approved standard applied at the normal recommended rate according to crop and soil type. Plot size varied between 1/300 - 1/600 ha.

Table 1

Trial	Location	Soil Type	Crop	Variety	Date Sown or Planted	Application Date
1976						
A	Spalding, Lincs.	V.F.S.L.	Bulb onions	Robusta	26.2	26.3
B	" "	"	"	"	26.2	24.3
C	Boston, Lincs.	"	"	Elsoms	1.3	7.4
D	Minster, Kent	S.L.	"	-	1.3	30.3
E	K. Lynn, Norfolk	F.S.	Peas	Vedette	23.2	10.3
F	" "	L.F.S.	"	Maro	26.2	11.3
G	Wickham market, Suffolk	S	"	Sparkle	17.3	2.4
H	" "	S	"	"	17.3	1.4
I	Benhall, Suffolk	L.F.S.	"	Maro	22.3	1.4
J	" "	L.F.S.	"	"	22.3	1.4
K	Birchington, Kent	Z.y.L.	Cauliflower*		16.7	22.7
L	Ramsgate, Kent	L	"		23.7	27.7
1977						
M	Sweffling, Suffolk	S	Bulb onions	Rijnsberger	26.3	9.4
N	" "	S	Brassica		26.4	28.4
O	" "	S	"		27.4	29.4
P	" "	S	Onion & leek		27.4	29.4
Q	" "	S	Brassica*			
R	" "	S	Leek*			
S	Elmstone, Kent		Cauliflower*	St. Hilary	22.7	27.7
T	Staple, Kent		" *	Nevada & Lawyna	22.7	27.7
U	Eastry, Kent		Broccoli *			
V	Wingham, Kent		" *			11.8
1978						
1	Boston, Lincs.	S.C.L.	Dutch cabbage	Hydena	13.5	15.5
2	Lythbury	Z.y.L.	Swede	Magnificiemt	14.5	16.5
3	York	V.F.S.L.	"	Tipperary	10.6	16.6
4	Boston, Lincs.	S.C.L.	Dutch cabbage	Hydena	13.5	21.6

* Transplanted crops

Logarithmic trials were unreplicated in 1976 with a plot size of 1 x 18.25 m. In 1977 treatments were replicated twice with a plot size of 2 x 20 m.

Trials numbered 1, 2, 3 and 4 were also of a randomised block design with four replicates apart from trial number 4 which had three replicates. Plot size was 20 m^2 (5 x 4 m). All experimental rates are expressed in kg a.i./ha.

b) Treatments

On trials B, H and J chlorthal-dimethyl was applied on a logarithmic scale from 18.0 to 1.5 kg/ha over a base rate of propachlor of 2.9 kg/ha, and propachlor on a logarithmic scale from 7.8 - 0.65 kg/ha over a base rate of chlorthal-dimethyl of 4.5 kg/ha.

On trial N chlorthal-dimethyl was applied on a logarithmic scale from 7.5 - 0.75 kg/ha over a base rate of propachlor at 4.4 kg/ha.

In 1976 two tank mixtures were applied to all replicated trials (A - L).

4.5 kg/ha chlorthal-dimethyl + 2.9 kg/ha propachlor
6.75 " " " + 4.4 " "

In 1977 trials M - V were treated with a single tank mix containing

4.5 kg/ha chlorthal-dimethyl + 4.4 kg/ha propachlor

In 1978 trials 1 to 4 were treated with two tank mixtures containing

3.0 kg/ha chlorthal-dimethyl + 4.55 kg/ha propachlor
4.5 " " " + 4.55 " "

Approved standard herbicides were applied according to label recommendations (Table 2).

Table 2

Standard treatments in kg product per ha

Trial	Treatment
A to D	3.4 kg pyrazone + chlorbufam
E	1.7 kg terbuthylazine + terbutryne
F to J	2.2 kg " + "
K to V	6.8 kg propachlor
1 to 4	7.0 kg "

c) Application

All lettered trials were sprayed pre-weed and crop emergence. Logarithmic trials were sprayed with a Chesterford Mini-Logarithmic sprayer at 315 l/ha, or with an AZO Logarithmic sprayer at 520 l/ha, using a boom fitted with fan nozzles. The base and 'logged' treatments were applied together, the base being used to dilute the logarithmically applied material. Randomised block trials were sprayed using an Allman motorised pump sprayer, fitted with fan nozzles on a 3 m boom. Water volume ranged from 580 to 800 l/ha.

Trials 1, 2 and 3 were applied pre-emergence to crop and weed within a week of drilling. Trial number 4 was applied post-emergence to the crop (at 5 - 6 true leaf stage) but pre-emergence to the weed. All treatments were applied at a water volume rate of 500 l/ha at a pressure of 1.4 bars with an Oxford Precision Sprayer. Metering of the product was through Teejet No. 3 11003 flat fan nozzles, mounted on a 5 jet 2 m boom assembly.

d) Assessments

i) Weed control

Each weed species present at each site was assessed 5 - 9 weeks after application by counting the number of seedlings present in a prescribed area, and the mean figures expressed as a percentage of the untreated control values.

In trials 1, 2 and 3 assessments were carried out 32 days after treatment, and 21 days after treatment in trial 4.

A second assessment was made three months after application at two sites (N and P) using a 0 - 10 scale, 0 = complete control, 10 = no control.

ii) Crop tolerance

Visual assessments of crop vigour were made on a 0 - 10 scale, 0 = crop dead and 10 = full vigour. Crop seedling counts per metre row length were made on direct drilled crops. Onion yields were recorded on trials A, C and M.

In trials 1 and 3 crop seedling vigour was estimated according to the BBA scale.

0 = No crop damage or thinning
10 = Complete crop kill

RESULTS

A. Weed Control

Weed control on trials A to V assessed 5 - 9 weeks after application - Table 3.

Table 3

Mean per cent control of weeds, pre-emergence

Weed species	1976 No. of sites	1976 Standard treatment	1976 Chlorthal-dimethyl + Propachlor kg a.i./ha 4.5+2.9	1976 Chlorthal-dimethyl + Propachlor kg a.i./ha 6.75+4.4	1977 No. of sites	1977 Standard treatment	1977 Chlorthal-dimethyl + Propachlor kg a.i./ha 4.5+4.4
Anagallis arvensis	1	100	100	90			
Capsella bursa-pastoris	5	89	74	91	6	96	81
Chenopodium album	5	77	86	96	5	69	100
Echium vulgare	2	100	100	100			
Fumaria officinalis	1	100	66	80			
Galium aparine	1	20	100	30			
Lamium spp					2	95	100
Matricaria recutita					2	76	93
Mercurialis annua	2	46	62	64	2	0	87
Papaver rhoeas					2	100	100
Poa annua	5	81	97	97	2	100	100
Polygonum aviculare	6	74	87	84	3	90	98
Polygonum convolvulus	7	64	51	22	2	0	95
Polygonum persicaria	1	1	81	98			
Raphanus raphanistrum	1	100	75	100	1	100	100

cont'd ...

Table 3 (cont'd)

Mean per cent control of weeds, pre-emergence

Weed species	1976 No. of sites	1976 Standard treatment	1976 Chlorthal-dimethyl + Propachlor kg a.i./ha 4.5+2.9	1976 Chlorthal-dimethyl + Propachlor kg a.i./ha 6.75+4.4	1977 No. of sites	1977 Standard treatment	1977 Chlorthal-dimethyl + Propachlor kg a.i./ha 4.5+4.4
Senecio vulgaris	2	36	48	0	5	91	81
Sinapis arvensis	1	99	71	90	1	10	48
Solanum nigrum					2	100	100
Sonchus arvensis					1	100	100
Stellaria media	7	73	94	96	5	62	95
Tripleurospermum maritimum	4	94	77	100	3	85	86
Urtica urens	3	55	83	99	3	99	100
Veronica spp	5	78	93	100	2	99	100
Viola arvensis	2	73	72	85	2	40	100
Mean Control		71.6	79.8	80.1		74.3	92.8

Control on trials 1 to 3 assessed 32 days after treatment - Table 4.

Table 4

Mean per cent control of broad-leaved weeds, pre-emergence

Weed species	No. of Sites	Propachlor kg a.i./ha 4.55	Chlorthal-dimethyl kg a.i./ha 3.0	Chlorthal-dimethyl kg a.i./ha 4.5	Chlorthal-dimethyl + Propachlor kg a.i./ha 3.0+4.55	Chlorthal-dimethyl + Propachlor kg a.i./ha 4.5+4.55
Capsella bursa-pastoris	1	87	47	93	80	87
Chenopodium album	2	35	64	39	37	52
Erysimum cheiranthoides	1	0	0	0	50	50
Fumaria officinalis	1	17	17	83	0	17
Lamium purpureum	1	84	54	48	56	99
Polygonum aviculare	1	22	29	58	36	43
Polygonum convolvulus	1	71	12	87	71	92
Polygonum lapathifolium	1	33	22	0	0	45
Stellaria media	2	84	47	60	97	64
Urtica urens	2	54	29	36	50	75
Mean Control		48.7	32.1	50.4	47.7	62.4

Weed control was assessed at two sites (N and P) three months after application on a 0 - 10 scale, 0 = complete control, 10 = no control - Table 5.

Table 5

Weed control at 3 months (mean of 2 sites)

	Propachlor 4.4 kg a.i./ha	Chlorthal 4.5 + Prop 4.4 kg a.i./ha
Capsella bursa-pastoris	3.3	1.7
Chenopodium album	6.5	0.0
Matricaria matricarioides	2.0	2.5
Papaver rhoeas	1.8	0.1
Poa annua	2.0	0.0
Polygonum aviculare	7.8	0.6
Polygonum convolvulus	8.5	1.3
Raphanus raphanistrum	6.7	6.7
Senecio vulgaris	0.6	1.3
Sisymbrium officinale	6.7	6.7
Solanum nigrum	5.1	0.3
Tripleurospermum maritimum	3.0	1.7
Veronica persica	0.0	0.0
Viola arvensis	10.0	0.0
Mean Weed Cover	47.7	15.7

Weed control 21 days after treatment applied to the crop post-emergence, but pre-weed emergence (trial 4) - Table 6.

Table 6

Per cent control of broad-leaved weeds - post crop emergence

Weed species	Propachlor kg a.i./ha	Chlorthal-dimethyl kg a.i./ha		Chlorthal-dimethyl +Propachlor kg a.i./ha	
	4.55	3.0	4.5	3.0 + 4.55	4.5 + 4.55
Polygonum aviculare	66	89	0	89	89
Polygonum convolvulus	37	72	0	44	44
Polygonum persicaria	85	42	29	98	96
Urtica urens	85	44	50	94	94
Mean Control	68.2	61.7	19.7	81.2	80.7

B. Crop Vigour and Yields

Table 7

i) Bulb onions

Onion seedling establishment and yields

Trials	Onion Seedling Nos. A	C	M	Yield (tonnes/ha) A	C	M
Untreated	22.9	22.7	26.4	9.3	2.8	2.0
Standard	22.0	21.7	27.1	9.7	15.8*	26.8**
Chlor 4.5 + Prop 2.9	24.0	25.5		14.6	17.6*	
Chlor 4.5 + Prop 4.4			24.9			48.4*†
Chlor 6.7 + Prop 4.4	23.7	25.7		17.0	16.6*	

* Significantly different from untreated at the 1% level
** " " " " " " 5% "
† " " " standard " " 10% "

ii) Transplanted brassicae

Table 8

Crop vigour at 2 months post treatment

Trials	1976 K	1976 L	1976 Mean	1977 S	1977 T	1977 U	1977 Mean
Untreated	9.3	9.3	9.30	9.0	8.3	9.3	8.87
Prop 4.4	9.3	9.0	9.15	8.7	8.6	7.7	8.33
Chlor 4.5 + Prop 2.9	8.7	9.0	8.85				
Chlor 4.5 + Prop 4.4				8.7	7.6	8.3	8.20
Chlor 6.7 + Prop 4.4	9.3	9.0	9.15				

0 = dead crop 10 = full vigour

iii) Direct drilled brassicae

Table 9

Seedling counts and crop vigour (trial 0)

Treatment	Seedling Nos. per m row A	B	C	Crop vigour (6 wks) A	B	C	Crop vigour (12 wks) A	B	C
Cauliflower	9.3	8.2	8.3	10.0	6.0	4.0	5.0	10.0	10.0
Calabrese	12.2	11.5	10.3	10.0	8.0	5.7	4.7	10.0	10.0
Cabbage	12.7	11.7	13.8	10.0	8.0	5.7	5.0	10.0	10.0
B. Sprouts	6.6	6.7	6.8	10.0	7.3	6.0	4.3	10.0	10.0
O.S. Rape	19.8	17.7	20.2	10.0	7.7	6.3	8.7	10.0	10.0
Turnip	16.7	13.0	11.8	10.0	6.3	5.3	8.7	9.3	10.0
Swede	13.3	14.5	14.8	10.0	6.3	6.3	8.0	8.7	10.0
Mean	12.9	11.9	12.3	10.0	7.1	5.6	6.3	9.7	10.0

Treatment A = Untreated control
" B = Propachlor @ 4.4 kg a.i./ha
" C = Chlorthal-dimethyl + propachlor @ 4.5 + 4.4 kg a.i./ha
0 = dead crop 10 = full vigour

Table 10

Crop-emergence and vigour 32 days post treatment (trials 1 and 3)

Treatment	kg a.i./ha	No. plants/m row White cabbage	Swede	Crop vigour White cabbage	BBA Swede
Untreated		5.5	8	1	0
Propachlor	4.55	5.5	8	1	1
Chlorthal-dimethyl	3.0	5.4	8	1	1
" "	4.5	5.8	8	1	1
Chlorthal + Prop	3.0 + 4.55	5.5	8	1	1
" + "	4.5 + 4.55	5.4	8	1	1

iv) Drilled leeks

Table 11

Crop stand and vigour scores

	Stand	Vigour (6 wks)	Vigour (12 wks)
Untreated	5.4	10.0	1.3
Propachlor 4.4	6.8	10.0	6.3
Chlor + Prop 4.5 + 4.4	4.5	8.3	10.0

0 = dead crop 10 = full vigour

DISCUSSION

1976 and 1977 were years of contrasting soil and weather conditions, the former being exceptionally dry whilst the spring of 1977 was cold and wet. Despite such extremes, the tank mix treatments performed well in both years and initially provided a level of control which in general was superior to the standards used, especially of *Chenopodium album, Mercurialis annua, Stellaria media, Urtica urens* and *Viola arvensis* (Table 3). Although the middle dose of the mixture was better than the low dose, little was gained by increasing the rates further.

Table 4 (1978) shows that the higher rate of chlorthal-dimethyl in the tank mix gave a better degree of weed control than the lower rate, especially of *Urtica urens* *Polygonum convolvulus* and *Chenopodium album* whereas the data in Table 6 shows that the tank mix applied post crop emergence had a less marked advantage over propachlor applied alone. There was no difference in weed control between the high and low rate of chlorthal-dimethyl in the tank mix.

The data presented in Table 5 clearly illustrates the benefits derived by the addition of chlorthal-dimethyl to propachlor, particularly in regard to the greater persistence which is of especial importance in autumn drilled onions where the crop needs not only a clean start but so far as is possible, weed free conditions right through to harvest. Roberts et al (1976) have demonstrated very clearly the value of the tank mix in this crop, both in terms of herbicidal efficacy, absence of damage and maintenance of yield. The tank mix had no adverse effect on germination of brassica cultivars but despite initial crop check, at one site (Table 9) caused both by the mixture and propachlor, this was outgrown 12 weeks after drilling by which time the crops displayed full vigour. In the absence of herbicide treatment, reduction in vigour due to weed competition was most noticeable.

As a result of this work which complements that of Roberts approval under the Agricultural Chemicals Approval Scheme has been obtained by the manufacturers for the tank mix of chlorthal-dimethyl (as Dacthal®) and propachlor (as Ramrod®) for pre-weed emergence use in all leaf and root brassica crops, dry bulb onions and leeks.

References

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EXPERIMENTS WITH REPEATED LOW DOSES OF AN IOXYNIL-LINURON MIXTURE ON ONIONS

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Summary The first trial was carried out on a crop of overwintered bulb onions grown on a light peat/loamy peat soil in 1977. A proprietary mixture of ioxynil-linuron was applied at ½, ¼ and ⅛ rates, ie 0.28, 0.14 and 0.07 kg a.i./ha, ⅛ rate applied every 14 days, other rates pro-rata; initial treatments were applied on 18 April.

The ⅛ dose, (0.07 kg a.i./ha) applied at 14 day intervals on five occasions gave good commercial weed control and had no deleterious effect on yield. This result was slightly better than that from the commercial herbicide programme represented in the control plots.

The second experiment was on bulb onions sown in March 1978 that had received pre-emergence herbicides. The post emergence ioxynil-linuron treatments at 0.28, 0.14 and 0.07 kg a.i./ha were initially applied on 24 April and repeated on each treatment independantly when the weeds were at the early cotyledon stage. By 23 June the ¼ rate treatment (0.14 kg a.i./ha x three applications) had given the best weed control and was superior to post emergence pyrazone + chlorbufam.

Résumé Le premier essai, ayant pour objet une culture d'oignons à bulbes, hivernée et cultivée dans un sol composé d'un mélange tourbe légère/tourbe limoneuse, fut entrepris en 1977. La spécialité désherbante mélangée fut appliquée à des dosages à ½, ¼ et ⅛, c'est à dire de 0.28, 0.14 et 0.07 kg m.a./ha. Le dosage à ⅛ fut appliqué tous les 14 jours, et les autres dosages au prorata; le traitement initial fut appliqué le 18 avril.

Le dosage à ⅛ (0.07 kg m.a./ha), appliqué cinq fois à des intervalles de 14 jours, donna un bon désherbage commercial sans diminution du rendement, qui fut légèrement supérieur à celui obtenu en utilisant un programme commercial de désherbage sur des parcelles-temoins.

Le deuxième essai fut conduit avec des oignons à bulbes semés en mars 1978, qui avaient reçu un traitement de pré-émergence d'herbicides. Un traitement de post-émergence d'ioxynil-linuron à des dosages de 0.28, 0.14 et 0.07 kg m.a./ha fut appliqué initialement le 24 avril, et chaque traitement fut répété indépendamment quand les mauvaises herbes avaient atteint la stade des cotylédons. Le 23 juin le dosage à ¼ (0.14 kg m.a/ha x 3 applications) avait donné le meilleur désherbage et était supérieur à un traitement de post-émergence de pyrazon + chlorbufam.

INTRODUCTION

Ioxynil + linuron is widely used, at manufacturer's recommended rates on peat soils as a herbicide with mainly contact action in onions at the 2-2½ leaf stage. It controls a wide spectrum of common weeds and only Poa annua, Agropyron repens and to a lesser extent Polygonum aviculare are resistant. It is one of the lower priced onion herbicides but it can cause some temporary yellowing of the leaf. To minimise this, low doses were applied at frequent intervals to small weeds (emergence to early cotyledon) in large onions, overwintered, on a designated time basis and to smaller spring sown onions, at intervals dictated by weed emergence and size.

METHODS AND MATERIALS

Each experiment used a randomised block design with three replicates. Individual plots were 10.08 m^2 comprising 4 rows of onions 38 cm apart in a field consisting of 91 cm of light peat/loamy peat over fen clay (Prickwillow series) containing up to 70% o.m.

The ioxynil + linuron (Certrol-lin) was applied as a HV spray (800 l/ha) with an Oxford Precision Sprayer.

The trial on overwintered onions, variety Senshyu Semi Globe Yellow drilled on 16 August, was delayed until 18 April in order for some weeds to emerge after the pre and post-emergence herbicide programme had left the crop very clean. At this date an average of 10 weeds at very small cotyledon stage were visible on each plot. The onions were growing rapidly and the foliage had recovered from winter damage. The control treatment in this experiment was one application of methazole at 2.5 kg a.i./ha. In the spring sown crop, of Hyduro drilled 9 March the ioxynil + linuron treatments were applied when the weeds were at the early cotyledon stage following a propachlor + chlorpropham + paraquat cocktail used pre-emergence of the crop.

A weed assessment on 29 April on the overwintered experiment consisted of five 0.5 m^2 quadrats per plot. Relative estimates of weed control at harvest were made by visual scoring of 0 (no weeds) to 5 (complete cover). Crop yields were recorded.

For the spring sown crop, plant counts were done on a designated row length and weed assessment expressed as percentage weed cover and of the standard post-emergence pyrazone/chlorbufam treatment.

Polygonum persicaria and Polygonum convolvulus were the main weeds in both trials.

RESULTS

Overwintered bulb onions, initial treatments applied 18 April 1977

On a weed assessment taken on 29 April no weeds were visible on any treatment.

Table 1

Population, yield and weed assessments at harvest

Rate (kg/ha a.i.) and frequency of application	Bulbs/m^2 at harvest	Marketable yield (t/ha) 40-60mm	60-80 mm	>80 mm	Total yield	Mean weed score* at harvest
	(± 1.96)	(± 0.92)	(± 1.82)	(± 1.09)	(± 1.36)	
0.28 once	50.8	15.3	41.9	6.1	63.4	2.3
0.14 twice	51.5	14.4	47.3	3.9	65.8	3.3
0.07 5 times	52.5	12.9	52.2	4.2	69.6	1.6
Control	51.8	12.6	50.8	4.9	68.5	4.6

* 0 = no weeds, 5 = complete cover

Weeds present at the assessment taken at harvest were only at the very small cotyledon stage and did not present any hindrance to plant development or harvesting. The highest weed score was on the control plots.

Yield and weed control improved with increased frequency/reduced dose herbicide application.

The one eighth treatment (0.07 kg a.i./ha) applied at 14 day interval gave the best weed control and the yield from this treatment was the highest in the trial. There was a significant reduction in yield from the half dose (0.28 kg a.i./ha) applied only once, ie 18 April but the five applications of 0.07 kg a.i./ha is a greater amount in total than the single half dose.

Spring sown bulb onions, initial treatment applied 24 April 1978

The 0.14 and 0.07 kg a.i./ha treatments were applied on 24 April when the onions were at the loop stage. 0.28 kg a.i./ha rate was applied on 28 April assuming that this would be strong enough to be more effective on slightly more advanced weeds. Pyrazone 1.125 kg a.i./ha + chlorbufam 0.9 kg a.i./ha (a standard commercial post-emergence treatment) was applied on 16 May. The second application of 0.07 kg a.i./ha ioxynil + linuron was applied on 18 May. The repeat 0.14 and 0.28 kg a.i./ha rates were applied on 22 May and 24 May respectively, when onions were at the two leaf stage. All three rates were applied again on 27 June.

Table 3

Effect of repeated low dose ioxynil + linuron on plant and weed population

Rate (kg a.i./ha) and frequency of application	Plants/m² 9 May	Plants/m² 30 May	Weed cover 23 June actual %	Weed cover 23 June as % of pyrazone + chlorbufam treatment
Hand weeded	78.3	70.7	1.3	8.0
0.28 x 3	80.0	67.7	8.0	48.3
0.14 x 3	89.7	83.3	8.3	48.3
0.07 x 3	87.0	82.0	15.0	88.3
Pyrazone 1.125 + chlorbufam 0.9 x 1 (control)	81.7	76.3	18.3	100.0

The ioxynil + linuron at 0.28 kg a.i./ha had a damaging effect on plant stand but the 0.14 and 0.07 rates compared favourably with the commercial standard pyrazone + chlorbufam. But in terms of weed control the 0.28 and 0.14 kg a.i./ha rate of ioxynil + linuron were identical whilst the lowest rate of this material gave reduced weed control. But all three rates gave better weed control than the single application of standard pyrazone + chlorbufam. Thus because of its lesser effect on plant stand the three applications of 0.14 kg a.i./ha ioxynil + linuron gave the best chemical weed control in this trial.

DISCUSSION

In the overwintered crop the ioxynil + linuron gave good weed control at very low cost for the last three months of crop life and is therefore most beneficial on soils that require an average 5-7 herbicide applications for the eleven month life of the crop.

For the small onions in the spring sown experiment, the repeated applications of low dose ioxynil + linuron proved a useful adjunct to the pre-emergence herbicide programme. This would be especially useful in a dry spring when on some occasions the pre-emergence application does not give long and complete weed control.

The one essential component is that the weeds for this low dose technique must be caught in very early stages of development, ie just emerged or at the small cotyledon stage, for on organic soils the action is mainly contact. Applications must be regulated by weed status not by designated elapsed time intervals.

It is not anticipated that these low dose ioxynil + linuron mixtures will stand as a comprehensive herbicide programme in their entirety for spring sown bulb onions and any resistant weed growth could easily be removed by another herbicide or tractor hoeing. Indeed in treating this material as a contact herbicide there would not be any residual action to lose with any form of cultivation.

Low doses of ioxynil + linuron offer a reduction in the escalating cost of herbicide programmes for onions.

Further work needs to be done on reducing the water volume and to determine the effect of low doses of ioxynil + linuron on hardiness in overwintered onions when the material is applied pre-winter.

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PRELIMINARY GLASSHOUSE EXPERIMENTS WITH VARIOUS HERBICIDES FOR SWEDES, CABBAGE AND CHICORY GROWING IN AN ORGANIC SOIL

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Summary Thirteen herbicides or herbicide mixtures were tested for selectivity in one or more of swedes, cabbage or chicory growing in an organic soil. Stellaria media L. was used to monitor weed control activity. The experiment was conducted in pots in a temperate glasshouse. Herbicide treatments were incorporated into the soil before planting, applied to the soil surface after planting or applied when the crop developed its first true leaves. Fresh weights of foliage were taken when the plants were approximately 6 cm high. Dinitramine at 0.75 kg a.i./ha incorporated gave the best results in swedes. In cabbage dinitramine at 0.75 kg a.i./ha incorporated and pendimethalin at 2.0 kg a.i./ha surface applied gave as good results as propachlor at 4.48 kg a.i./ha surface applied or desmetryne at 0.42 kg a.i./ha applied post-emergence. Surface applications of chlorpropham at 2.0 kg a.i./ha and chlorpropham plus asulam at 3.0 kg a.i./ha plus 2.0 kg a.i./ha respectively were the most promising in chicory.

Résumé La sélectivité de 13 herbicides, appliqués seuls ou en mélanges, a été déterminée dans une ou plus des cultures suivantes en sols humifères: chou-navet, chou et chicorée. Le Stellaria media L. a servi pour contrôler l'activité herbicide. Toutes les plantes se trouvaient en pots en serre tempéré. L'application des herbicides s'est déroulé selon un des protocoles suivants: en pré-semis avec incorporation au sol; sans incorporation en post-semis; au stade des premières feuilles véritables. Le poids frais du feuillage a été mesuré lorsque les plantes avaient 6 cm de hauteur. Dans le chou-navet, le traitement le plus efficace était la dinitramine à 0,75 kg m.a./ha avec incorporation. Dans le chou ce même traitement, ainsi que le pendimethalin à 2 kg m.a./ha appliqué en superficie, ont donné des résultats pareils à ceux du propachlor à 4,48 kg m.a./ha en superficie, ou bien du desmétryne à 0,42 kg m.a./ha en post-levée. Des traitements superficiels avec chlorprophame + asulame à 3 kg + 2 kg m.a./ha ont offert les meilleures perspectives en culture de chicorée.

INTRODUCTION

Swede, cabbage and chicory will grow well in the organic fens of East Anglia but weeds are a problem. Few of the herbicides used in these crops on mineral soils give completely effective weed control on organic soils. The experiments described in this paper compared some newer herbicides with those herbicides that are used on mineral soils and which have some weed control activity on organic ones. Dinitramine (Richardson and Dean, 1974), pendimethalin (Richardson and Dean, 1975), isoproturon (Richardson et al., 1977), 3,6-dichloropicolinic acid (Richardson and Parker, 1977) and pyridate (Richardson and Parker, 1978) have shown some selectivity in brassicas growing on mineral soils. Benfluralin (Daniau and Béraud, 1976), dinitramine, dimefuron (van Himme and Stryckers, 1975), chlorpropham plus asulam (Stryckers and van Himme, 1974) and chlorpropham plus carbetamide (Bourdin et al., 1975) have shown some selectivity in chicory growing on mineral soils. Of the newer herbicides dinitramine (May, 1972), pendimethalin (May, 1973), isoproturon, dimefuron (May, 1975) and 3,6-dichloropicolinic acid (May, 1978) have all shown weed control activity on organic soils.

The glasshouse experiments described here used these herbicides and others on one or more of swede, cabbage or chicory growing in an organic soil with *Stellaria media* L. included as a test species for weed control activity. This weed was chosen as it is easily grown in pots, is common on organic soils and should be susceptible to the majority of herbicides in these experiments.

METHOD AND MATERIALS

The herbicides, their formulations, doses and time of application are given in Table 1 and the treatments and species in Table 2. All doses quoted in this

Table 1

Compound	Formulation	Doses in kg a.i./ha	Incorporated	Surface	Post-emergence
nitrofen	(24% w/v e.c.)	2.0, 4.0	-	✓	✓
'Benazolox'*	(35% w/v e.c.)	1.3, 2.6	-	✓	✓
pendimethalin	(35% w/v e.c.)	1.0, 2.0	✓	✓	-
dinitramine	(24% w/v e.c.)	0.75, 1.5	✓	✓	-
isoproturon	(75% w/w w.p.)	1.5, 3.0	-	✓	✓
pyridate	(50% w/w w.p.)	1.0, 2.0	-	✓	-
propachlor	(65% w/w w.p.)	4.48, 8.96	-	✓	-
chlorpropham	(40% w/v e.c.)	2.0, 4.0	-	✓	✓
chlorpropham plus carbetamide	(40% w/v e.c. plus 70% w/w w.p.)	1.2 + 2.1 2.4 + 4.2	-	✓	✓
benfluralin	(18% w/v e.c.)	1.1, 2.2	✓	-	-
dimefuron	(50% w/w w.p.)	0.375, 0.75	-	✓	✓
chlorpropham plus asulam	(40% w/v e.c. plus 40% w/v e.c.)	1.5 + 1.0 3.0 + 2.0	-	✓	✓
desmetryne	(25% w/w w.p.)	0.42, 0.84	-	✓	✓

* 'Benazolox' is a proprietary mixture of benazolin and 3,6-dichloropicolinic acid

Table 2

Compound	Plants Tested			
	Swede	Cabbage	Chicory	*Stellaria media*
nitrofen	✓	✓	-	✓
'Benazolox'	✓	-	-	✓
pendimethalin	✓	✓	-	✓
dinitramine	✓	✓	✓	✓
isoproturon	✓	-	-	✓
pyridate	✓	-	-	✓
propachlor	✓	✓	-	✓
chlorpropham	-	-	✓	✓
chlorpropham plus carbetamide	-	-	✓	✓
benfluralin	-	-	✓	✓
dimefuron	-	-	✓	✓
chlorpropham plus asulam	-	-	✓	✓
desmetryne	-	✓	-	✓

paper are in kg a.i./ha. Each species was tested as a separate experiment but all four experiments were conducted on the same dates using identical materials and conditions. All species were grown in 6.4 cm diameter pots filled with an organic fine sandy loam (19% organic matter content, pH 5.6). The soil was part of a 50 tonne sample of top soil taken from Mepal, Cambridgeshire on 17 March 1977 and stored in a large open topped pit dug into a field at the W.R.O.

Eight cabbage (var. Primo), eight swede (var. Acme), eight chicory (var. Bataille) or fifteen *S. media* seeds were sown per pot. For each experiment all pots were placed in randomised blocks in a temperate glasshouse (mean temperature 24°C, maximum 29°C, minimum 15°C). Four replications of each treatment were used. The incorporated treatments were sprayed on open top metal trays 19 cm by 14 cm by 6.4 cm deep. These treatments were thoroughly mixed by inversion of the soil three times through a large plastic funnel before the soil was placed in the pots and the seeds planted. All spray applications used the W.R.O. pot sprayer fitted with an 8002E 'Spraying Systems Teejet' delivering 366 l/ha at 2 bars pressure.

The incorporated and surface treatments were applied on the day the seeds were planted, 23 March 1978. The post-emergence treatments were applied on 18 April 1978 when all the crop plants had just developed their first true leaves. At this time the *S. media* had approximately six true leaves. Naturally occurring weeds were removed at regular intervals during the experiment.

Growth was assessed when untreated plants were 6 cm high. This was 12 May 1978 for swedes, 17 May for cabbage, 18 May for chicory and 23 May for S. media. The foliage was cut at soil level and fresh weights taken. Plant numbers were recorded at this harvest and also 28 days after sowing (incorporated and surface treatments only).

RESULTS

The fresh weights of foliage per pot were transformed to $\log_{10}(10x+1)$ for statistical reasons. For economy of space and simplicity only compounds that significantly affected plant growth are included (Table 3). The detransformed data are omitted because only comparisons between treatments and the control are required. Herbicide effects on plant numbers were similar to those for plant fresh weights and so are also omitted.

Only dinitramine of the incorporated treatments controlled S. media and it did not significantly affect any of the crop species. Pendimethalin and benfluralin both failed to control the weed. However, when applied to the soil surface, pendimethalin at 2.0 kg/ha did control S. media and did not significantly affect swede or cabbage. Propachlor at both 4.48 and 8.96 kg/ha surface applied also controlled the weed and did not significantly reduce the weights of swede or cabbage. The other surface applied treatments that controlled S. media were chlorpropham at 2.0 and 4.0 kg/ha, chlorpropham plus carbetamide at 2.4 plus 4.2 kg/ha respectively and chlorpropham plus asulam at 3.0 plus 2.0 kg/ha respectively and these treatments did not significantly affect chicory. Isoproturon did not control the weed but at 3.0 kg/ha it did significantly reduce the fresh weight of swedes. Nitrofen, 'Benazolox', dinitramine, pyridate, dimefuron and desmetryne when surface applied did not control S. media. Post-emergence treatments of 'Benazolox' and isoproturon controlled S. media and did not significantly reduce swedes. Desmetryne at both rates controlled the weed and did not significantly affect cabbage. Dimefuron at 0.75 kg/ha controlled S. media and did not affect chicory. Nitrofen, chlorpropham, chlorpropham plus carbetamide and chlorpropham plus asulam did not control S. media.

DISCUSSION

This experiment only monitored the early growth stages of the plants and as with all glasshouse experiments the results cannot be directly related to field conditions. However they do give some indications of treatments for weed control in swede, cabbage and chicory growing on organic soils. Although Bataille variety of chicory was used the results could well apply to both forcing and processing cultivars. There is little evidence of any large variations in herbicide effects between the two varieties. However as with all plants, variations in herbicide tolerance between cultivars may vary and any further testing should bear this in mind.

Dinitramine incorporated gave the best results in swedes but both propachlor and pendimethalin surface applied also gave good results. The good weed control by pendimethalin when surface applied but not when incorporated was unexpected because like dinitramine it is usually much more active incorporated than surface applied (May, 1973). No logical explanation can be offered for this. Both 'Benazolox' and isoproturon applied post-emergence gave good weed control and did not reduce the fresh weight of swedes. However the use of isoproturon in this crop may be risky. Applied pre-emergence it significantly reduced the fresh weight of swedes and at 3.0 kg/ha applied post-emergence a fresh weight reduction was recorded.

Table 3

Fresh weight of plant foliage per pot

Chemical	Dose in kg a.i./ha	Weight in grammes transformed to $\log_{10}(10x+1)$ Swede	Cabbage	Chicory	*Stellaria media*
Incorporated Treatments					
dinitramine	@ 0.75	0.443	0.791	0.265	0.01*
"	@ 1.5	0.647	0.825	0.259	0 *
control - untreated		0.546	0.710	0.270	0.469
S.E.		±0.1050	±0.1128	±0.0517	±0.1053
Surface Treatments					
pendimethalin	@ 1.0	0.488	0.726	-	0.315
"	@ 2.0	0.586	0.746	-	0.075*
isoproturon	@ 1.5	0.444	-	-	0.421
"	@ 3.0	0.205*	-	-	0.151
propachlor	@ 4.48	0.408	0.953	-	0.037*
"	@ 8.96	0.416	0.811	-	0.075*
chlorpropham	@ 2.0	-	-	0.661	0.075*
"	@ 4.0	-	-	0.668	0 *
chlorpropham plus carbetamide	(@ 1.2 + 2.1	-	-	0.534	0.180
	(@ 2.4 + 4.2	-	-	0.554	0.037*
chlorpropham plus asulam	(@ 1.5 + 1.0	-	-	0.647	0.151
	(@ 3.0 + 2.0	-	-	0.643	0.075*
control - untreated		0.532	0.686	0.477	0.294
S.E.		±0.0838	±0.0896	±0.0748	±0.1001
Post-emergence Treatments					
'Benazolox'	@ 1.3	0.507	-	-	0.064*
"	@ 2.6	0.562	-	-	0.156*
isoproturon	@ 1.5	0.445	-	-	0 *
"	@ 3.0	0.204	-	-	0 *
desmetryne	@ 0.42	-	0.621	-	0 *
"	@ 0.84	-	0.661	-	0.011*
dimefuron	@ 0.375	-	-	0.593	0.398
"	@ 0.75	-	-	0.612	0.197*
control - untreated		0.466	0.766	0.499	0.495
S.E.		±0.0907	±0.0819	±0.0970	±0.1063

* significantly different from the control at P> 0.05

In cabbage dinitramine incorporated gave good selectivity as did pendimethalin surface applied. These compared well with propachlor surface applied or desmetryne post-emergence.

Chicory was also unaffected by dinitramine incorporated or by chlorpropham, chlorpropham plus carbetamide or chlorpropham plus asulam surface applied or dimefuron post-emergence. However the largest fresh weights were from chlorpropham and chlorpropham plus asulam surface applied.

The promising compounds mentioned above all warrant further testing under field conditions in their relevant crops.

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THE DEVELOPMENT OF SULFALLATE FOR THE CONTROL OF COMPOSITE WEEDS IN DRILLED AND TRANSPLANTED LETTUCE IN THE UNITED KINGDOM

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Summary Experiments over 5 years in the Thames Valley market garden area of Oxfordshire and Berkshire show that the control of *Senecio vulgaris* (groundsel) can be improved by increasing the dose of sulfallate. The standard recommended dose is 2.03 kg ai/ha. Up to twice this dose appears safe on the drilled lettuce crop and three times the dose on block raised transplants.

Résumé Une expérimentation pendant 5 annees dans la région maraîchère de la vallée de la Tamise (Oxfordshire et Berkshire) a démontré que il est possible d'obtenir une meilleure destruction du seneçon commun (*Senecio vulgaris*) en augmentant la dose du sulfallate. La dôse normale recommandeé et de 2,03 kg m.a./ha. Il parait possible d'employer la dose double dans les laitues semées en place et la dose triple sur les plants en motte.

INTRODUCTION

Chemically it is always difficult to control weeds of the same botanical family as the crop, especially with residual herbicides. The problem is even more pronounced where an inadequate rotation is followed. Thus in the intensive lettuce growing areas of the Thames Valley, *S. vulgaris* and *Matricaria matricarioides* (pineappleweed) often form the major weed problem.

In 1974, the authors observed that though the technical data sheet for sulfallate gave *S. vulgaris* as a susceptible weed, at the dose recommended the control was commercially unacceptable. Communication with the manufacturers revealed that cost of material as much as weed control efficiency had played a part in deciding the dose of this product during its early life in the 1950's. Since then circumstances have changed allowing relatively higher monetary imputs into weed control in the crop. Therefore it was decided to look at higher doses in an attempt to control composite weeds. Other chemicals known to control composite weeds were also included in some of the trials, but only sulfallate has been used throughout the series.

Commercial sulfallate is available in the United Kingdom only in a mixture with chlorpropham, therefore sulfallate has been used with and without the addition of chlorpropham. Also, as sulfallate does not control cruciferous weeds, propyzamide has been included in the trials for the control of *Capsella bursa-pastoris* (shepherd's-purse), a very common market garden weed. These two herbicides are known to have no significant effect on composite weeds and the interaction between them and sulfallate is not considered in this report.

METHODS AND MATERIALS

Seven trials were conducted from 1974 to 1978, at three different holdings. Five were on drilled crops, when the herbicides were applied within one or two days of drilling, and two on block raised transplants when the herbicides were applied the day before planting by hand. All trials were conducted on summer crops, drilled or planted between April and July. A 'butterhead' variety was used in all trials except the sixth when a 'crisp' variety was used. The soil was a fine sandy loam overlying gravel at all sites except in trial 3 where it overlay Bagshot sand.

All trials were laid out as randomised blocks with 3 replicates of all treatment combinations except the first trial which had only 2 replicates. Replication of the sulfallate treatments ranged from 3 to 9, the higher replications occurring where bulking of treatment combinations has been possible.

Where herbicide combinations were used they were applied as tank mixes. Application was made with a pressurised knapsack sprayer, the volume of application varying from 600 to 2000 litre/ha according to the weather conditions, higher volumes being necessary under windy conditions. A standard plot size of 10 m^2 was used throughout the trials.

Using fixed lengths of row, crop emergence records were made on four of the drilled crops. Weed counts were made either using quadrats 250 mm^2 taking 8 counts per plot, or 12 counts of a 200 mm^2 quadrat.

Counts were made of a) *S. vulgaris*; b) mayweeds, with no attempt being made to differentiate between the seedlings of *Matricaria matricarioides*, *Matricaria recutita* (scented mayweed) and *Tripleurospermum maritimum* subsp. *inodorum* (scentless mayweed); c) *C. bursa-pastoris*; and d) other weeds. Yield data was taken from the last two trials only.

RESULTS

The effect of increasing doses of sulfallate on plant stand is given in Table 1. the effect on yields is presented in Table 2 and Table 3 shows the effect on the germination of *S. vulgaris*.

Table 1

Effect on plant stand

No. of plants per 4 metre length of row

Trial No.	Dose of sulfallate (kg a.i./ha) 0	2.03	2.24	2.80	3.36	3.92	4.06	4.48	5.08	6.09	S.E.±
2	37.33	40.50	-	-	36.50	37.67	-	38.17	-	-	2.208
3	41.10	43.70	-	-	-	42.70	-	41.40	40.10	-	4.72
4	30.00	23.70	-	-	-	-	21.00	-	21.50	23.20	2.40
5	39.83	42.33	-	-	-	-	40.67	-	41.17	41.17	1.953

Trial 2 and 3 were conducted in 1975 under dry warm conditions. This may have caused some chemical to be vaporized off the soil surface, thereby reducing the effective dose. Certainly, the lack of any effect on weeds in trial 3 (Table 2) suggested this might be so. There were no significant differences in plant stands between any of the treatments or where the treatments were compared with the control in any of the trials undertaken on drilled crops. However in the fifth trial all the doses of sulfallate gave a reduction in stand which nearly reached significance when compared with the control. In this trial the herbicide was applied to moist soil and heavy rain followed application.

Table 2

Effect on Yield

Mean weight (kg) per trimmed head of lettuce

Trial No.	Doses of sulfallate (kg a.i./ha) 0	4.06	6.09	S.E.
6		0.4212	0.4796	± 0.0191
	0.4217 S.E. ± 0.0135			
7		0.1813	0.2002	± 0.0087
	0.1742 S.E. ± 0.0062			

In both trials headweight improved with the increasing dose of sulfallate. This was due to improvement in weed control. In trial 6 the difference between the higher dose of sulfallate and either the lower dose, or the untreated control was significant.

Table 3

Effect on Senecio vulgaris

No. of seedlings per $\frac{1}{4}$ square metre

Trial No.	Dose of sulfallate (kg a.i./ha) 0	2.03	2.24	2.80	3.36	3.92	4.06	4.48	5.08	6.09	S.E. ±
1	45.70	28.40	33.90	26.10	17.40	13.20	-	-	-	-	5.57
2	18.30	13.30	-	-	9.20	8.00	-	5.20	-	-	2.51
3	2.00	2.22	-	-	-	1.62	-	2.89	1.56	-	0.894
4	65.20	52.30	-	-	-	-	12.80	-	9.70	11.20	6.36
5	12.33	13.00	-	-	12.00	6.00	-	6.83	-	-	2.01
6	18.70	-	-	-	-	-	3.70	-	-	1.30	8.44
7	28.00	-	-	-	-	-	13.30	-	-	9.30	5.72

In trial 1 all treatments significantly reduced the weed count compared with the untreated.

In the second trial, the three highest doses were significantly different from the untreated, and the highest dose significantly superior to the lowest dose. No significant differences were obtained in the third trial. In the fourth trial, the differences between the three highest doses and the lowest were highly significant. The fifth trial showed a similar pattern to the fourth, but the differences did not quite reach significance.

In the sixth and seventh trials, because of the presence of other treatments which are not reported in this paper, only two doses of sulfallate were included. Thus although weed levels were markedly reduced in keeping with the effect of these levels in the other trials, the difference did not reach significance.

The occurrance of mayweeds in the trial areas proved to be very scattered and irregular, and none of the differences in the control of this weed reached significance and the data is not included in this report.

DISCUSSION

Sulfallate is only available commercially in the UK in mixture with chlorpropham which when used at the recommended dose applies 2.03 kg a.i./ha of sulfallate and 0.28 kg a.i./ha of chlorpropham. In the first five experiments the dose of sulfallate was increased keeping the dose of chlorpropham constant at 0.28 kg a.i./ha. Also included was propyzamide at 0.56 a.i./ha as an alternative to and in addition to the chlorpropham. There was no apparent interaction between the chemicals in the control of composite weeds or on plant stand. Propyzamide clearly gave the best control of C. bursa-pastoris, another important weed of intensive market gardens. Therefore all the later trials were based on comparing increased doses of sulfallate in combination with a standard dose of propyzamide.

Effect on plant stand

Although none of the experimental results reached significance, some puckering and twisting of the leaves occurred on seedlings at the dose of 3.92 kg a.i./ha in the first trial and the effect on plant stand in the fourth trial indicated that the safe limit had been reached so far as drilled crops were concerned. This observation is supported by local practice where not more than one and half to twice the standard dose is used. In addition one commercial grower, sowing/planting sequential crops on the same land severely checked the third crop (drilled) in the sequence where sulfallate at between 3.36 and 4.06 kg a.i./ha had been used on each crop, and a build up of the herbicide had occurred.

Effect on yield

Since 1978 with the increase in transplanting rather than drilling of lettuce, the experiments have been carried out on transplants raised in peat blocks. It is known that sulfallate must be used pre-planting of the crop. In trials 6 and 7 the plants have been planted by hand using a trowel. Top soil is thus moved aside and root contact with the herbicide is avoided. Yield records taken from these two transplanted trials both showed a consistent improvement in head weight with the use of higher doses of sulfallate, which reached a significant level in the first trial.

It would appear that doses of 6.09 kg a.i./ha that is three times the recommended dose, may be applied safely pre-planting to trowel planted outdoor summer lettuce. However, the main commercial method of planting block raised transplants is with a machine which sets the block in a hole pressed in the soil, so that root contact with the herbicide remains and this may reduce plant tolerance.

Effect on weed control

Because of the irregular occurrance of the weeds, the results in some of the trials did not reach a significant level. Nevertheless there are clear trends to indicate that by using higher doses, between 3.36 and 6.09 kg a.i./ha, a better control of S. vulgaris was achieved. The results in trials 6 and 7 with transplanted crop were affected by this method of planting. In the plots receiving the higher dose of sulfallate, most of the weeds occurred along the planting line where the soil had been disturbed during transplanting.

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PERSISTENCE OF CHLORTHAL-DIMETHYL ACTIVITY IN SOIL

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Summary In six experiments on a sandy loam at different times of year, combinations of chlorthal-dimethyl at 3.4 - 6.7 kg a.i./ha with propachlor at 2.2 - 4.4 kg a.i./ha gave consistently good control of the initial flush of annual weeds. After counting, paraquat was applied and the effects on subsequent weed emergence determined. Propachlor usually had little activity, but chlorthal-dimethyl gave high percentage kills, even at 3.4 kg a.i./ha. Application in May gave appreciable kill of weeds appearing in a third flush in autumn, while application in August killed some of the weeds emerging in the following spring. Residue determinations by gas-liquid chromatography confirmed the relative persistence of chlorthal-dimethyl. When applied in May the half-life was about 100 days, while of the amount applied in October 55% was still present in the following April.

INTRODUCTION

Experiments with mixtures of propachlor and chlorthal-dimethyl for broad-spectrum pre-emergence weed control in onions have given encouraging results (Roberts et al., 1976, 1978) and led to the development of a commercial tank-mix recommendation. In these experiments it appeared that one advantage of the chlorthal-dimethyl component was its more persistent activity in soil. In order to examine this, further experiments were made using a simple method to determine the effects of combinations of different rates of the two herbicides on successive flushes of weed seedlings appearing on soil which was undisturbed after initial seedbed preparation. Some determinations of residue levels of chlorthal-dimethyl in soil were also made, and the results are summarized in this report.

METHODS AND MATERIALS

Weed emergence experiments

There were six experiments begun at different times of year in which the persistence of activity of propachlor/chlorthal-dimethyl combinations was determined by measuring the effect on successive flushes of weed seedlings. Seedbeds were prepared on a sandy loam with about 2% o.m., plots of 1.8 x 1.5 m marked out, and the spray treatments applied immediately in a volume of 1120 l/ha. Propachlor at 4.4 kg a.i./ha and chlorthal-dimethyl at 10.1 kg a.i./ha were included, together with a range of combinations of the two herbicides at different rates, and there were two untreated control plots in each of the three replicate randomized blocks per experiment.

After about 4 weeks or longer when the first flush of emergence appeared to be complete, counts were made of the surviving plants of each weed species either on the whole plot or in ten 15 x 15 cm quadrats per plot, depending on the density. The whole experiment was then sprayed with paraquat and all vegetation killed. The plots were left undisturbed, and when a further flush of seedling emergence had taken place the count was repeated and the experiment again sprayed. In the Tables the results for the treatments are given as percentage reductions in total weed numbers from those on the untreated control plots.

Persistence of soil residues

Separate field plots (6 x 1.5 m) were sprayed with chlorthal-dimethyl at 4.0 kg a.i./ha on 2 May and 17 October 1977. Three replicate plots were prepared on each occasion and immediately after herbicide application, 30 cores (2.5 cm diameter to a depth of 7.5 cm) were taken from each plot at random positions. The cores from each plot were bulked, thoroughly mixed by passing several times through a 2-mm mesh sieve and the total weight of sieved soil recorded. Further soil samples were taken at intervals during the subsequent 4 to 9 months. The herbicide concentrations in the soils were determined by gas-liquid chromatography using a Nickel-63 electron-capture detector (Walker, 1978).

RESULTS

Weed emergence experiments

In three experiments carried out in 1975 and 1976 there were four rates of propachlor combined with four rates of chlorthal-dimethyl (Table 1).

Table 1

Effect of propachlor (P) and chlorthal-dimethyl (C) on weed emergence

	% kill																	
Kg a.i. /ha	Applied 23 July 1975						Applied 17 September 1975						Applied 13 April 1976					
C	0	3.4	5.0	6.7	8.4	10.1	0	3.4	5.0	6.7	8.4	10.1	0	1.7	3.4	5.0	6.7	10.1
	Counted 16 September						Counted 16 October						Counted 2 June					
P 0	-	-	-	-	-	29	-	-	-	-	-	87	-	-	-	-	-	60
2.2	-	92	72	93	86	-	-	99	99	100	100	-	-	86	88	92	98	-
2.9	-	94	98	89	93	-	-	99	100	100	100	-	-	87	96	96	100	-
3.6	-	95	96	94	100	-	-	100	100	100	100	-	-	96	98	92	95	-
4.4	100	98	98	99	100	-	98	100	100	100	100	-	94	91	96	98	96	-
6.6	100	-	-	-	-	-	100	-	-	-	-	-	98	-	-	-	-	-
Control density	$9/m^2$						$1580/m^2$						$81/m^2$					
	Counted 16 October						Counted 24 February						Counted 4 October					
P 0	-	-	-	-	-	83	-	-	-	-	-	97	-	-	-	-	-	87
2.2	-	86	61	83	85	-	-	94	99	98	96	-	-	64	65	91	89	-
2.9	-	75	65	89	92	-	-	92	90	96	99	-	-	37	81	89	92	-
3.6	-	77	56	79	81	-	-	93	98	96	96	-	-	9	66	88	89	-
4.4	61	90	74	89	92	-	23	94	97	97	92	-	3	36	77	84	86	-
6.6	52	-	-	-	-	-	70	-	-	-	-	-	21	-	-	-	-	-
Control density	$138/m^2$						$180/m^2$						$97/m^2$					

The first experiment was begun during a dry spell and there was only a sparse initial weed emergence, mainly Poa annua, Capsella bursa-pastoris and Stellaria medi Propachlor performed well, however, and gave complete kill at 4.4 kg/ha. Overall kil with chlorthal-dimethyl was poor, with C. bursa-pastoris, Tripleurospermum maritimum ssp. inodorum, Senecio vulgaris and some P. annua surviving. The combined treatments all gave good results, although the percentage kill decreased at the lower rates of propachlor. There was much greater weed emergence in September after rain, and the main species were the same with the addition of Veronica persica. Propachlor killed V. persica and most Poa annua, but much of the Stellaria media remained. Chlorthal-dimethyl killed these three species, but not Senecio vulgaris, Capsella bursa-pastoris or Tripleurospermum maritimum ssp. inodorum. This last species was irregularly distributed and accounted for much of the variation in the values for the combined treatments (Table 1). There was, however, consistently good overall kill with chlorthal-dimethyl at 6.7 kg/ha and above.

In the second experiment there was a very high initial density, notably of Poa annua together with Stellaria media, Tripleurospermum maritimum ssp. inodorum and Lamium amplexicaule. Propachlor and the combined treatments gave virtually complete kill, and with chlorthal-dimethyl alone only T. maritimum ssp. inodorum and a few P. annua remained. Counts made in February of the weeds which had appeared in late autumn showed that chlorthal-dimethyl and all the combinations had given high kills (Table 1), and that although propachlor at 4.4 kg/ha alone had little effect, at 6.6 kg/ha some activity had remained.

The main species appearing initially in the third experiment were Matricaria recutita, Stellaria media, Senecio vulgaris and Poa annua. Propachlor alone killed these, and the survivors were mainly Polygonum aviculare and Fumaria officinalis. Chlorthal-dimethyl alone did not kill M. recutita or S. vulgaris, but the combined treatments all gave good results. During summer there was a long drought period, with no rain until the end of August. An appreciable flush of seedling emergence took place in September, again mainly P. annua, S. media and M. recutita with Aphanes arvensis and other species. Propachlor had little effect, but chlorthal dimethyl gave good results except for M. recutita. The percentage kill with combinations involving 5.0 kg/ha equalled that with 10.1 kg/ha, and even where only 3.4 kg/ha had been applied there was fairly good weed control.

Three further experiments were made in 1977 in which the effects of a restricted range of herbicide combinations was observed on successive flushes of seedling emergence. In the first of these the initial weed flora comprised mainly Poa annua, Stellaria media, Trifolium repens and Chenopodium album, with Polygonum aviculare, Solanum nigrum and other species. Propachlor alone gave good control, with only isolated T. repens, P. aviculare and Fumaria officinalis remaining. Chlorthal-dimethyl alone was less effective, with some P. annua surviving as well as T. repens and F. officinalis. The combined treatments were generally rather better than either herbicide alone (Table 2). Chenopodium album was the main species in the second flush, together with T. repens, P. annua and Solanum nigrum. Chlorthal-dimethyl alone was more effective overall than propachlor alone, killing C. album and S. nigrum. The mixtures killed S. nigrum and some C. album, but some T. repens survived on all treatments. The species in the third flush were mainly P. annua, Stellaria media, Senecio vulgaris and Aphanes arvensis. Propachlor alone had little effect, but chlorthal-dimethyl at 10.1 kg/ha killed all P. annua, S. media and A. arvensis with only S. vulgaris and a few T. repens surviving. The mixtures gave percentage kills approaching that with chlorthal-dimethyl at 10.1 kg/ha, though they were rather less with only 3.4 kg/ha (Table 2).

In the experiment begun in May 1977, the main species initially were Chenopodium album, Fumaria officinalis, Veronica persica, Stellaria media and Solanum nigrum. F. officinalis was not affected by any treatment, but chlorthal-dimethyl killed more of the other species than did propachlor and the mixtures were better than either herbicide alone (Table 2). At the second count, Poa annua and S. media were the main species, with V. persica and Lamium purpureum. Propachlor had little effect but chlorthal-dimethyl, even at the lowest rate applied, killed most of the weeds.

Table 2

Effect of propachlor (P) and chlorthal-dimethyl (C) on successive flushes of weed emergence in three experiments in 1977

		% kill														
kg a.i. /ha		Applied 14 April					Applied 18 May					Applied 23 August				
	C	0	3.4	5.0	6.7	10.1	0	3.4	5.0	6.7	10.1	0	3.4	5.0	6.7	10.1
		Counted 19 May					Counted 12 July					Counted 27 September				
P	0	-	-	-	-	72	-	-	-	-	70	-	-	-	-	94
	2.9	-	98	93	97	-	-	74	76	81	-	-	97	98	98	-
	4.4	94	98	98	99	-	43	76	85	87	-	90	98	99	99	-
Control density		353/m²					76/m²					173/m²				
		Counted 12 July					Counted 12 September					Counted 19 December				
P	0	-	-	-	-	84	-	-	-	-	99	-	-	-	-	95
	2.9	-	73	69	67	-	-	91	82	95	-	-	78	84	86	-
	4.4	34	56	67	73	-	13	91	85	92	-	0	79	69	84	-
Control density		78/m²					138/m²					92/m²				
		Counted 12 September					Counted 25 November					Counted 17 May				
P	0	-	-	-	-	88	-	-	-	-	91	-	-	-	-	57
	2.9	-	75	83	84	-	-	75	69	75	-	-	28	20	57	-
	4.4	25	73	84	84	-	0	78	47	88	-	0	15	35	52	-
Control density		99/m²					46/m²					66/m²				

P. annua was also the main species to emerge in autumn, together with S. media and Aphanes arvensis. By this time there was no effect at all from propachlor, but chlorthal-dimethyl again gave a high level of control.

The weeds in the final experiment were initially Poa annua, Stellaria media, Aphanes arvensis and Sonchus asper, with some Rumex crispus and Capsella bursa-pastoris. At the first count, all treatments had given kills of more than 90%. With propachlor alone R. crispus survived, with some S. media and a few P. annua. With the combined treatments only isolated S. media survived, together with Fumaria officinalis and Thlaspi arvense which were present on all plots at low density. During autumn the main species which emerged were P. annua and S. media, with a few F. officinalis and C. bursa-pastoris. There was no effect from propachlor, but chlorthal-dimethyl killed all the weeds except for F. officinalis and C. bursa-pastoris. At the lower rates in the mixtures there were only a few surviving P. annua and S. media in addition, with little difference between rates (Table 2). In this experiment the residual effects of the treatments on spring-germinating weeds were examined, and a count was made in May. The main species involved were S. media Polygonum aviculare, F. officinalis and Lamium amplexicaule. The numbers of weeds that established on the plots originally treated with chlorthal-dimethyl alone were less than half those on the untreated plots, and were mainly F. officinalis and Medicago lupulina. There was little difference in weed kill between 10.1 and 6.7 kg/ha, and even with lower initial rates of chlorthal-dimethyl there was some reduction in seedling numbers of susceptible species (Table 2).

Persistence of soil residues

The amounts of chlorthal-dimethyl remaining in the top 7.5 cm of soil from applications made in spring and autumn are shown in Table 3.

Table 3

Soil residues of chlorthal-dimethyl after spring and autumn applications

Date sampled	Days after application	Amount determined kg/ha	% of initial
2 May	0	4.2 ± 0.29	100
9 June	38	4.0 ± 0.58	95
4 July	63	2.8 ± 0.49	67
11 August	101	2.6 ± 0.62	62
9 September	128	1.9 ± 0.41	45
17 October	0	4.7 ± 0.24	100
6 April	171	2.6 ± 0.36	55
7 July	263	0.5 ± 0.19	11

These results indicate an appreciable degree of persistence of chlorthal-dimethyl in the soil. Approximately half the amount applied in early May remained until September, and half that applied in mid-October persisted throughout the winter.

DISCUSSION

Chlorthal-dimethyl and propachlor are to an appreciable extent complementary in terms of weed species killed, and the degree of control of the initial flush of seedlings depended very much on the composition of the weed flora. In four of the six experiments the weeds were mainly propachlor-susceptible, and in these propachlor alone gave higher percentage kills than chlorthal-dimethyl alone. The mixtures gave percentage kills little different from those with propachlor alone, even when the propachlor rate was halved (Table 1). In the experiments sprayed on 18 May and 23 August 1977, however, chlorthal-dimethyl at 10.1 kg/ha gave higher percentage kills than propachlor at 4.4 kg/ha and the mixtures gave better results than either herbicide applied alone (Table 2).

Propachlor had generally little effect on the second flush of weed seedlings, and increasing the rate from 4.4 to 6.6 kg/ha did not always increase the percentage kill (Table 1). Chlorthal-dimethyl at 10.1 kg/ha, however, consistently killed more than 80% of the weeds in the second flush, and the lower rates in the mixtures also gave high percentage kills. There was no trend related to the amount of propachlor in the mixture, and except for the low rate of 1.7 kg/ha (Table 1), little difference between rates of chlorthal-dimethyl. Average values were 85.0, 80.4 and 87.8% for 3.4, 5.0 and 6.7 kg/ha respectively, compared with 90.8 for 10.1 kg/ha. There was also appreciable kill of weeds in the third flush attributable to chlorthal-dimethyl applied in April and May 1977, while application in August killed *Polygonum aviculare* and some other species emerging in the following spring (Table 2).

These results confirm the relatively short persistence of propachlor in the soil, and show that chlorthal-dimethyl is appreciably more persistent. This is also apparent from the results of the residue determinations (Table 3). The results from the spring application support the statement that the half-life is about 100 days (Martin & Worthing, 1977). As with other herbicides, the rate of degradation is influenced by the soil temperature and moisture content (Walker, 1978). The negligible loss between 4 July and 11 August (Table 3) appears to have been the result of inadequate soil moisture; only 13.7 mm of rain fell during this period. During winter, less than half the herbicide was lost so that activity against spring-germinating susceptible species would be expected, and was found (Table 2).

Despite this appreciable persistence, it seems unlikely that chlorthal-dimethyl used at the rates envisaged in mixtures with propachlor will cause problems in relation to following crops. Of the fifteen crops examined in field screening tests at NVRS, lettuce, spinach and red beet were the most susceptible, but the maximum soil residue levels for crop safety were not established.

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