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POST-EMERGENCE HERBICIDE TREATMENTS ON ONIONS AND LEEKS

R. T. Hewson and H. A. Roberts
National Vegetable Research Station, Wellesbourne, Warwick

Summary In field trials on a sandy loam, various herbicides were examined as post-emergence treatments on drilled onions and leeks in an attempt to obtain weed control throughout crop life without recourse to cultivation or hand weeding. The herbicides were applied following pre-emergence treatment with propachlor + paraquat/diquat. In some instances satisfactory weed control was achieved with pyrazone + chlorbufam applied at the post-crook or 1-leaf stages, and yields were obtained which did not differ significantly from those of weeded controls. Phenmedipham, nitrofen, aziprotryne, desmetryne, dinoseb-acetate and methabenzthiazuron could not be applied safely at a stage sufficiently early to give effective weed control and at later stages phenmedipham and dinoseb-acetate gave variable crop injury. Ioxynil octanoate reduced stands when applied at the 1-leaf stage, but after the 2-3 leaf stage did not affect yield. It is concluded that ioxynil could be valuable as a second post-emergence treatment.

INTRODUCTION

The use of residual pre-emergence herbicides for weed control in drilled onions and leeks has become accepted commercial practice. It is recognised, however, that no single application provides sufficiently complete and long-lasting control, and much attention has been paid to programmes in which two or more treatments are applied (Cassidy & Doherty, 1968; Whitwell, 1969). This report describes experiments at Wellesbourne in which several herbicides with varying degrees of contact and residual activity were compared as post-emergence treatments on bulb onions, salad onions and drilled leeks which had received uniform pre-emergence treatment.

METHODS AND MATERIALS

The experiments were of randomised block design, with plots of 5-10 yd^2 and three or four replicates. The soil was a sandy loam (16% clay, 6% silt, 2% O.M.). The herbicides were standard commercial formulations, the volume rate was 100 gal/ac and doses are given as lb/ac a.i. Except where stated, a uniform application of propachlor 3.9 lb + paraquat/diquat 0.5 lb/ac was made shortly before emergence. The post-emergence sprays were applied at different growth stages. In some experiments, all the plots were weeded; in others, only the control plots were weeded, so that the practical success of the treatments could be determined. Weed kill was assessed by counting survivors in a number of random quadrats on each plot, and both weed kill and crop injury were scored visually on a scale of 0 (no effect) to 10 (complete kill). Crop stands and total marketable yields were recorded and are expressed as percentages of the values for the weeded controls. Those significantly less than the control values are indicated by single (P = 0.05) or double (P = 0.01) asterisks.

RESULTS

The results of two experiments on bulb onions in which post-emergence sprays were applied at two stages of crop growth are shown in Table 1. Although the pre-emergence spray killed most of the weeds, an average of 12/ft^2, mainly Chenopodium album and Polygonum convolvulus, remained at the time of post-emergence treatment. In the first experiment only the control plots were weeded; in the second, the treated plots were also weeded after the weed kill had been assessed. By this time some competition had occurred, so that unless the weed control had been very good, yields were reduced.

Table 1

Post-emergence treatments on drilled bulb onions (cv. Rijnsburger Bola) 1969

Herbicide	(lb/ac)	Leaf number	Weed kill (0-10)	Crop injury (0-10)		Unweeded crop		Weeded crop	
				June	July	Stand (%)	Yield (%)	Stand (%)	Yield (%)
Ioxynil	0.75	1	9.5	5.7	4.4	62**	67**	62**	72**
"	0.75	2-3	7.3	3.3	1.4	92	58**	89	79**
Phenmedipham	1.0	2-3	6.3	4.1	3.3	-	37**	92	57**
Nitrofen	3.1	1	8.6	2.7	1.8	84*	82	77**	89
"	3.1	2-3	5.3	0.7	1.0	-	36**	89	73**
Aziprotryne	1.78	1	9.5	1.3	0.6	90	92	86*	93
"	1.78	2-3	3.7	0.2	1.0	-	36**	89	73**
Desmetryne	0.38	1	8.0	1.0	0.0	90	78*	94	95
"	0.38	2-3	3.9	0.2	0.4	-	36**	100	79**
Dinoseb-acetate	2.4	2-3	7.0	4.9	1.2	98	70**	100	88
Methabenzthiazuron	3.0	1	9.7	6.5	5.3	43**	37**	66**	73**
Methabenzthiazuron	3.0	2-3	7.5	3.5	1.2	102	74*	92	85*
Pyrazone chlorbufam	0.75 + 0.60	1	8.3	0.8	0.3	97	90	95	93
Pyrazone chlorbufam	0.75 + 0.60	2-3	0.8	0.2	0.6	-	20**	88	68**

Ioxynil (Totril) at 0.75 lb/ac caused severe injury and reduced crop stand at the early stage, although weed control was excellent. At the later stage, stand was not affected and the early damage was outgrown, but because of competition from large plants of Polygonum aviculare and from some P. convolvulus which recovered, yields were reduced. Phenmedipham at 1 lb/ac at the 2-3 leaf stage caused appreciable injury without giving effective weed control. Nitrofen at 3.1 lb/ac gave good weed control when applied early, and although stands were reduced, there was no significant depression in yield. At the later stage there was negligible injury but poor weed control. Aziprotryne gave similar results; yields were not depressed by the early application but weed control at the later stage was very poor. Desmetryne at 0.38 lb/ac gave negligible injury, but only when it was applied early on the plots subsequently weeded was there no yield depression. Dinoseb-acetate at 2.4 lb/ac applied at the 2-3 leaf stage caused only slight injury and did not affect stand. Where these plots were weeded there was no significant yield depression. Methabenzthiazuron at 3 lb/ac caused severe damage at the 1-leaf stage and with all treatments the yields were reduced. Pyrazone + chlorbufam (Alicep) gave good weed control at the 1-leaf stage and in neither experiment were the yields significantly less than those from the hand-weeded controls. With later applications there was virtually no weed control.

In a third experiment, several post-emergence treatments were applied to plots which had received either propachlor at 3.9 lb/ac or pyrazone at 0.75 + chlorbufam at 0.60 lb/ac as a pre-emergence treatment. The treated plots were not weeded and the stands and yields (Table 2) are expressed as percentages of those from weeded plots which had received the appropriate pre-emergence treatment.

Table 2

Combined treatments on drilled bulb onions (cv. Rijnsburger Bola) 1969

Post-emergence herbicide	(lb/ac)	Pre-em. propachlor				Pre-em. pyrazone + chlorbufam			
		Weed kill (0-10)	Crop Injury (0-10)	Crop Stand (%)	Crop Yield (%)	Weed kill (0-10)	Crop Injury (0-10)	Crop Stand (%)	Crop Yield (%)
Pyrazone chlorbufam	0.75 + 0.60	8.9	0.3	94	96	-	-	-	-
Propachlor	3.9	-	-	-	-	8.0	0.8	98	89
Ioxynil	0.75	8.5	1.0	99	84*	9.4	4.5	75**	75**
Phenmedipham	1.0	6.8	2.8	97	58**	8.8	4.3	88**	74**
Aziprotryne	1.78	6.5	0.0	95	60**	8.5	2.0	99	88
Nitrofen	3.1	6.8	0.5	99	85*	8.8	1.7	89*	88

Propachlor and pyrazone + chlorbufam applied post-crook; others at 2-3 leaf stage.

The main weeds were *Urtica urens*, *Stellaria media*, *Poa annua*, *Trifolium repens*, *Fumaria officinalis*, *Polygonum aviculare* and *P. convolvulus*, with a total density of 18/ft^2. Pre-emergence pyrazone + chlorbufam gave much better control (83%) than did propachlor (52%), which was ineffective against *Fumaria officinalis*, *Polygonum aviculare* and *P. convolvulus*. Propachlor did not affect the crop, and although pyrazone + chlorbufam reduced early vigour, none of the plants was killed and final yield of the weeded plots was not affected. None of the post-emergence treatments which followed propachlor reduced crop stand, but only pyrazone + chlorbufam applied at the post-crook stage gave effective weed control. Plants treated with ioxynil, aziprotryne and phenmedipham suffered competition from *P. aviculare* and *T. repens*, while nitrofen did not control *Stellaria media*, *T. repens* or *F. officinalis*. Where propachlor followed pyrazone + chlorbufam, weed control was less complete than that with the reverse combination, though the yield was not significantly reduced. The other four post-emergence treatments gave good weed control when applied after pre-emergence pyrazone + chlorbufam. Because of the reduced vigour of the crop caused by this pre-emergence treatment, however, injury was more severe than that which occurred when these treatments followed propachlor. Ioxynil, phenmedipham and nitrofen all reduced the stand when applied after pre-emergence treatment with pyrazone + chlorbufam.

Table 3

Post-emergence treatments on over-wintered salad onions (cv. White Lisbon) 1969

Herbicide	(lb/ac)	Leaf number	Weed control Oct. (%)	Weed control May (0-10)	Crop Injury (0-10)	Crop Yield (%)
Propachlor	3.9 pre-em.		81	7.3	0.0	78*
Propachlor	3.9 pre-em.					
followed by:						
Pyrazone + chlorbufam	0.75 + 0.60	1	98	9.5	0.0	109
Prometryne	0.38	1	98	9.0	0.0	102
Dinoseb-acetate	2.0	1	100	9.2	1.0	95
Dinoseb-acetate	2.0	2-3	100	9.5	5.3	72**
Aziprotryne	1.78	2-3	99	9.3	2.3	88
Desmetryne	0.38	2-3	99	9.2	3.7	80*
Ioxynil	0.75	2-3	100	9.3	3.7	91
Nitrofen	3.1	2-3	97	8.0	2.3	81*
Control unweeded						30**

Several post-emergence treatments were compared on salad onions drilled in August for over-wintering and sprayed with propachlor at 3.9 lb/ac pre-emergence. Although propachlor alone gave good control of the weeds, mainly *Stellaria media*, *Poa annua* and *Veronica persica*, competition from those which survived or emerged later resulted in a yield significantly less than that from the weeded control (Table 3). All the post-emergence treatments appreciably improved the weed control, and at harvest in May 1970, most of the plots were very clean. On the unweeded control plots (average 8 weeds/ft^2) the weeds grew vigorously in spring and yield was reduced by more than two-thirds.

Neither pyrazone at 0.75 + chlorbufam at 0.60 lb/ac nor prometryne at 0.38 lb/ac caused any crop injury, while dinoseb-acetate at 2.0 lb/ac applied at the 1-leaf stage also had little adverse effect. At the 2-3 leaf stage, dinoseb-acetate caused much greater injury and significantly depressed yield; this may have been associated with warm, sunny conditions following a period of rain. The remaining four treatments all caused some visible injury, but with aziprotryne at 1.78 lb/ac and ioxynil at 0.75 lb/ac the yields did not differ significantly from those of the weeded controls. With nitrofen at 3.1 lb/ac, the effect on yield was probably the result of competition from surviving *Stellaria media*.

In three experiments, post-emergence treatments were applied to drilled leeks following a pre-emergence application of propachlor + paraquat/diquat. Two were drilled in March, and in one of these the treated plots were not weeded; the third was drilled at the beginning of May and all plots were weeded. The results are shown in Table 4.

In these experiments, the only treatments to cause significant reductions in stand or of the yield of the weeded crop were ioxynil at 0.75 lb/ac, nitrofen at 3.1 lb/ac and methabenzthiazuron at 2.0 lb/ac, all applied at the 1-leaf stage. In the unweeded experiment, pre-emergence treatment gave very good weed control, but there were still approximately 4 weeds/ft^2 remaining in June, mainly *Polygonum aviculare*, *P. convolvulus* and *Fumaria officinalis* together with some *Chenopodium album* and other species. The only treatments which gave a weed control score of more than 7.0, assessed at the end of July were ioxynil at 0.75 lb/ac and methabenzthiazuron at 2.0 lb/ac applied at the 1-leaf stage. Both reduced the stand

Table 4

Post-emergence treatments on drilled leeks (cv. Musselburgh) 1969

			Drilled March				Drilled May		
Herbicide	(lb/ ac)	Leaf number	Unweeded		Weeded		Leaf number •	Weeded	
			Stand (%)	Yield (%)	Stand (%)	Yield (%)		Stand	Yield
Ioxynil	0.75	1	81*	70**	88	92	2	107	107
"	0.75	2-3	98	75**	112	122	2½-3	100	106
Phenmedipham	1.0	1	-	-	-	-	2	103	102
"	1.0	2-3	97	85*	111	102	2½-3	102	91
Nitrofen	3.1	1	82	66**	74**	86*	2	92	97
"	3.1	2-3	103	79*	103	108	2½-3	97	95
Aziprotryne	1.78	1	101	80*	105	115	2	94	96
"	1.78	2-3	99	67**	98	99	2½-3	94	102
Desmetryne	0.38	1	95	54**	104	107	2	94	111
"	0.38	2-3	96	66**	104	114	2½-3	87	101
Dinoseb-acetate	2.4	1	-	-	-	-	2	117	111
"	2.4	2-3	101	70**	111	114	2½-3	104	104
Methabenzthiazuron	2.0	1	76*	99	86*	97	2	-	-
"	2.0	2-3	100	86	98	93	2½-3	-	-
Pyrazone chlorbufam	0.75 + 0.60	1	98	82*	107	115	2	106	112
Pyrazone chlorbufam	0.75 + 0.60	2-3	94	38*	117	107	2½-3	97	118

of leeks, although with methabenzthiazuron yield was not affected. The same two herbicides applied at the 2-3 leaf stage, together with pyrazone + chlorbufam at the 1-leaf stage, gave satisfactory weed control.

DISCUSSION

It is accepted that the first step in a chemical weed control programme for drilled onions and leeks is the application of a residual pre-emergence herbicide. From experiments with bulb onions on silt soils, Whitwell (1969) concluded that for this purpose propachlor and pyrazone + chlorbufam were the most satisfactory herbicides. The results obtained at Wellesbourne confirm this conclusion, but in view of the checks to crop growth which occasionally occur with pyrazone + chlorbufam, even at a dose lower than that normally recommended, propachlor is preferred on this soil. Best results have been obtained when propachlor is combined with paraquat/diquat and applied shortly before emergence. This ensures that all seedling weeds already present are killed, and can often account for an appreciable proportion of the potential population of the more tolerant species such as Fumaria officinalis and Polygonum spp. which would not be controlled by propachlor alone.

There are two main approaches to subsequent treatment. One possibility involves inter-row cultivation in late May with hand-weeding in the rows, followed by a second application of a residual herbicide (Kirton Experimental Horticulture Station, 1970). This technique is satisfactory provided that hand labour is available at the right time. In the present experiments, it has been assumed that it would be desirable to eliminate the need for hand-weeding altogether.

In salad onions drilled in August for over-wintering, this objective was achieved. Where pyrazone + chlorbufam followed the pre-emergence treatment, the plots remained virtually weed-free until harvest in the following May (Table 3). The same combination of treatments was also successful in bulb onions (Tables 1 and 2), where the weed control was sufficient to ensure that yields were not significantly less than those from the weeded controls. In leeks, however, weed competition was not entirely eliminated (Table 4). It appears to be important that if some weeds survive the pre-emergence treatment, pyrazone + chlorbufam should be applied as soon as the crop has passed the crook stage.

Phenmediphan consistently caused foliar scorch of onions and would appear too damaging for use in this crop; the yields of weeded leek crops were not affected by application at the 2-3 leaf stage. Nitrofen at the 1-leaf stage reduced the stand of both onions and leeks (Tables 1 and 4), while at later stages weed control was inadequate. It has been shown previously that onions and leeks possess some tolerance to aziprotryne (Cassidy & Doherty, 1968; Roberts & Hewson, 1968) and this was confirmed in the present experiments. Although some crop injury occurred, on only one occasion was there any reduction in stand, when the herbicide was applied at the 1-leaf stage (Table 1). Weed control was good at this stage. This treatment appears quite promising, but further evidence of crop safety under a wide range of conditions is needed.

Earlier experiments at Wellesbourne demonstrated the selectivity shown in onions by desmetryne applied after the 1-leaf stage, and Cassidy & Doherty (1968) reported encouraging results. It is clear, however, that quite severe scorch can occur occasionally even when the treatment is applied at the 2-3 leaf stage (Table 3). The effect of dinoseb-acetate on the crop also appears to be very dependent on the conditions prevailing. Methabenzthiazuron at 2.0 or 3.0 lb/ac gave excellent weed control when applied to onions and leeks at the 1-leaf stage, but the stands were significantly reduced (Tables 1 and 4). It is possible that lower doses, found promising in New Zealand (Cox, 1969), may prove sufficiently selective.

Ioxynil octanoate was included in a number of experiments in 1968 and was consistently found to be more selective in onions than bromoxynil octanoate or the mixture of the two referred to by Simmonds (1968). Applied at the 1-leaf stage, ioxynil caused severe crop injury and reduced the stand (Tables 1 and 4). When applied after the crop had passed the 2-3 leaf stage, there was always some scorch and distortion of the leaf tips, but this did not affect the yields.

The results indicate that in any attempt to secure effective weed control in drilled onions or leeks by chemical means alone it is essential to follow up the pre-emergence spray with an early post-emergence treatment. Of the herbicides examined, pyrazone + chlorbufam appeared most satisfactory for this purpose. In some instances, it was sufficiently effective to ensure that the crop could be left without further treatment and a yield obtained comparable with that from the hand-weeded controls. If application was delayed, however, the weeds rapidly became tolerant. The problem with the other herbicides was that they were not safe enough for application at an early stage when the weeds were still susceptible, and by the time the crop had become tolerant, so had the weeds. There was also the disadvantage of variable effects on the crop depending on the growing conditions; damage was also more severe where the crop had been checked by the pre-emergence spray (Table 2).

The ability of ioxynil to kill large plants of certain species which have escaped the pre- and early post-emergence treatments appears to have practical value. In 1970, it was used very successfully to remove large plants of Fumaria officinalis in this way. Where Polygonum spp., and especially P. aviculare, are present, however, it seems essential to obtain a very high degree of control with the pre- and early post-emergence treatments; once plants had become established, control could not be obtained with any of the herbicides examined.

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POST-EMERGENCE WEED CONTROL IN DRILLED ONIONS

J. C. Cassidy and F. S. MacNaeidhe*
Kinsealy Research Centre, Dublin.5.

Summary Aziprotryne at 2.0 lb/ac was the most selective of a number of mainly contact herbicides examined for post-emergence application in drilled onions in experiments carried out during 1969 and 1970. The crop was less tolerant of ioxynil octanoate at 0.5 and 1.0 lb/ ac up to the 2 leaf stage but when the onion plants had developed 3 true leaves no significant damage occurred with this herbicide. Good selectivity and effective weed control, particularly of *Poa annua*, were obtained with VCS-438 (2-(3',4'-dichlorophenyl-4-methyl- 3,5-diketo-1,2,4-oxadiazole)at 2.0 lb/ac. CP 52665 (2-chloro-N-(isopropoxymethyl)-2', 6' acetoxylidide) at 1.5 lb/ac was also promising for early post-emergence application in onions grown on peat soil.

Simazine at 0.5 - 1.5 lb/ac as a pre-harvest treatment gave excellent weed control but all doses caused slight depression in final yields.

Results with dinoseb-acetate, phenmedipham, nitrofen, haloxydine and desmetryne are also included.

INTRODUCTION

The problem of achieving season long weed control in drilled onions with the use of repeated applications of residual type herbicides and the need for a good selective contact herbicide for post-emergence application has already been discussed (Cassidy and Doherty 1968). Work has continued on the screening of herbicides for control of weeds after crop emergence and the results of the trials carried out in 1969 and 1970 are described in this paper.

METHODS AND MATERIALS

Experiments were conducted at Kinsealy on a medium loam soil (clay 23.0%, O.M. 6.5%) an on fen peat (94% O.M.) at the Peatland Research Station, Lullymore. A randomised block desig was used with four to six replicates and plot size was 5 yd x 2 yd. Treatments were applied at a volume of 40 - 60 gal/ac using a pressure retaining knapsack sprayer. All doses are given as lb/a a.i. One to three visual assessments of treatment effect on crop and weeds were made. Plant or bulb counts were made in the Kinsealy experiments and yields were recorded at both centres. Wee kill was assessed by counting survivors in a number of random quadrats on each plot. At Kinsealy in 1969, plots in all experiments received a weed control programme based on chlorbufam/pyrazone/paraquat applied pre-emergence and propachlor/chlorpropham post-emergence before the application of experimental treatments. The post-emergence application of propachlor/chlorpropham was omitted in the trial areas in 1970.

RESULTS

1969 experiments

Five herbicides with mainly contact action were applied at different stages of crop growth in three experiments at Kinsealy. The main purpose of these experiments was to examine the selectivity of the herbicides for post-emergence application in drilled onions.

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* Present address : Peatland Research Station, Lullymore, Co. Kildare.

In the first experiment the crop (c.v. Robusta) was sprayed 20 days after emergence when 50% of the onion seedlings were showing the first true leaf. Treatments were applied under warm (air temp. 15.6°C), dry (relative humidity 68%) weather conditions. Rainfall was insignificant for the three days prior to and after spraying. Results are given in Table 1.

All treatments caused crop injury and reduced plant stand. Most severe effects occurred where nitrofen at 4.0 lb and ioxynil octonoate at 1.0 lb/ac were applied. Plant stand was reduced by over 60% in plots treated with these herbicides. Least damage was caused by aziprotryne at 2.0 lb/ac but nevertheless final stand was only approximately 75% of untreated areas adjoining the experiment. Plants which survived this treatment made a good recovery and final yields were commercially acceptable. Levels of crop injury were too high and the period of recovery too long with both ioxynil octanoate at 0.5 lb and phenmedipham at 1.0 lb/ac.

In the second experiment, treatments were applied five weeks after emergence when the crop had a well developed second true leaf (about 2 in.). At time of spraying, conditions were dry but humidity was high (82%). Almost 0.5 in. rainfall was recorded in the three days prior to application but the weather remained dry afterwards. The same treatments were also applied in the third experiment at the 3 - 4 leaf stage of the crop: eight weeks after emergence. Conditions were relatively cool (air temp. 13°C) and overcast, with a relative humidity of 72% at time of application. Slight rainfall (0.3 in.) occurred during the two days prior to spraying and 0.6 in. on the third day after spraying. Results are given in Table 1.

Table 1

Effect of treatments on crop vigour, plant stand and yield, Kinsealy 1969

Treatment	Dose lb/ac	Experiment 1			Experiment 2			Experiment 3		
		A*	B	C	A*	B	C	A*	B	C
Ioxynil octanoate	0.50	7.6	3.5	15.6	7.8	5.0	22.3	9.2	6.0	23.7
"	1.00	5.0	2.1	13.0	6.3	4.0	20.0	8.6	5.0	22.7
Aziprotryne	2.00	9.0	4.4	18.7	9.7	6.8	27.2	9.1	5.9	24.6
Desmetryne	0.25	8.6	4.0	14.9	8.8	6.6	24.6	9.7	5.8	23.6
Nitrofen	4.00	4.0	2.3	12.0	8.4	6.3	24.1	7.9	6.0	22.8
Phenmedipham	1.00	8.0	3.6	15.5	6.3	5.0	19.3	8.5	6.2	22.4
S.E. of treatment mean (df=20)			0.27	1.29		0.49	1.72		0.34	1.04
Mean no. plants/ft^2 and yield in areas immediately adjacent to the experimental sites			6.0	22.0		7.0	23.5		6.0	23.0

A Crop rating B No. onion plants/ft^2 C Yield (tons/ac)

* Crop rating scale : 0 (complete kill) - 10 (no damage)

Assessments taken approximately three weeks after application of treatments in all experiments.

Tolerance to all herbicides increased considerably at these later stages of growth. Aziprotryne at 2.0 lb/ac was again the most selective treatment and except for very slight tip scorch, which was evident for about three weeks after application, no crop injury occurred. Desmetryne at 0.25 lb/ac was also highly selective. Nitrofen at 4.0 lb, phenmedipham at 1.0 lb and ioxynil octanoate at 1.0 lb/ac caused severe crop scorch and reduction in vigour, particularly when applied at the 2 leaf stage but plots treated with nitrofen recovered more rapidly than those treated with the other herbicides. The lower dose of ioxynil octanoate also damaged the onion plants at the 2 leaf stage. Scorching and twisting of the foliage occurred and onion stand was reduced by both doses of ioxynil octanoate and phenmedipham (Table 1) at this stage of application. At the 3 - 4 leaf stage however, no reduction in plant stand occurred with any treatment and final yields were highly satisfactory (Table 1). There were few weeds in the experimental areas and it was difficult to give an accurate assessment of the comparative effectiveness of the different herbicides. However, of the more selective materials viz. aziprotryne and desmetryne, the former gave more effective and longer lasting weed control.

At Lullymore on a completely organic soil, treatments were applied when the third true leaf was 3 - 4 in. long, nine weeks after crop emergence. In addition to the five herbicides included in the Kinsealy experiments, mixtures of phenmedipham/ioxynil octanoate, nitrofen/ioxynil octanoate and nitrofen/phenmedipham were also tested. Crop tolerance to the various treatments was similar to that observed at Kinsealy except that phenmedipham and ioxynil octanoate were more selective. Weeds were a much greater problem on the peat soil and the principal species were *Polygonum persicaria*, *Poa annua* and *Senecio sylvaticum*. These were advanced in growth (3 - 9 in. high) when treatments were applied. Poor control of *P. persicaria* was obtained with all treat- Ioxynil octanoate 1.0 lb/ac was very effective against *S. sylvaticum*, while the mixture of nitrofen at 2.0 lb/ac + ioxynil octanoate at 0.5 lb/ac gave satisfactory control of *P. annua*.

1970 experiments

In 1970, aziprotryne at 2.0 lb/ac and ioxynil octanoate at 0.625 lb/ac were further evaluated for application at the crook - 1 leaf and 4 - 5 leaf stages of growth at Kinsealy. Three other herbicides, dinoseb-acetate at 2.4 lb, haloxydine at 0.5 lb and VCS-438 at 2.0 lb and 4.0 lb/ac were also included in these experiments. In a third experiment the use of simazine and mixtures of aziprotryne + simazine were examined for pre-harvest weed control in drilled onions.

In the first experiment, treatments were applied when 50% of the onion seedlings were developing the first true leaf. No rainfall occurred during the week prior to spraying, relative humidity was generally low (*ca* 70%) and the period of sunshine each day was higher than normal. Similar weather conditions also prevailed during the week after spraying.

Results are given in Table 2. With the exception of haloxydine at 0.5 lb/ac which caused severe initial scorch and reduced plant numbers, all treatments showed a high level of selectivity. Weed population was low in the trial area. The main weeds in order of prevalence were *Poa annua* *Lamium purpureum* and *Fumaria officinalis*. VCS-438 gave satisfactory prolonged control of *L. purpureum* and *P. annua* but was not effective against *F. officinalis*. Ioxynil octanoate, dinoseb-acetate, aziprotryne and haloxydine had little effect on *P. annua*.

Table 2

Effect of treatments applied at crook - 1 leaf stage on crop and weeds, Kinsealy 1970

Treatment	Dose lb/ac	Yield tons/ac	No. of onions/ft^2	Assessments 29 May 1970 Crop	Assessments 29 May 1970 Weeds	Assessments 20 July 1970 Crop	Assessments 20 July 1970 Weeds	% weed kill *Poa annua*	% weed kill *Lamium purpureum*
Aziprotryne	2.0	18.2	6.1	9.3	8.6	9.6	7.9	15	62
Ioxynil octanoate	0.625	16.3	5.6	9.4	8.5	9.4	6.4	0	64
Dinoseb acetate	2.4	16.1	5.2	9.3	8.0	9.5	6.6	8	40
VCS 438	2.0	17.3	5.8	9.4	8.5	9.6	8.6	88	89
PP 493	0.5	13.4	4.6	5.9	9.1	9.1	7.9	30	80
Control (hand-weeded)		13.1	5.6	10	2.8	8.8	5.3	0	0
S.E. of treatment mean (df = 15)		1.49	0.34						
Weeds/ft^2 in control plots								2.5	2.3

Rating scale : Crop; 0 (complete kill) - 10 (no damage);
Weeds; 0(dense cover of weeds) - 10 (no weeds)

In the second experiment, treatments were applied when the fifth true leaf was appearing and the first leaf was 10 - 12 in. high. Showers fell prior to and after spraying and the soil was damp. Although weeds were not numerous in the trial area, those present were advanced in growth (3 - 7 in. high). The main species in order of prevalence were Poa annua, Lamium purpureum, Chenopodium album, Capsella bursa-pastoris, Senecio vulgaris and Sonchus oleraceus.

Results are given in Table 3. When assessments were made nine days after application of treatments, haloxydine at 0.5 lb/ac was the only herbicide which had caused appreciable crop damage. Onion foliage was severely yellowed and scorched with this treatment. Some tip scorch also occurred with the other materials, particularly with ioxynil octanoate at 0.625 lb and VCS-438 at 4.0 lb/ac but was not serious and the crop quickly outgrew this effect.

Weed counts recorded three weeks after spraying showed that good control of all species was obtained with the different treatments except for Poa annua which was susceptible only to VCS-438. Of a number of new herbicides tested for early post-emergence application in onions at Lullymore on peat soil in 1970, CP 52665 at 1.5 lb/ac was particularly promising. This chemical was selective at the crook - 1 leaf stage and also gave satisfactory prolonged control of Stellaria media, Rumex acetosella and Poa annua.

Table 3

Effect of treatments applied at 4 - 5 leaf stage on crop and weeds, Kinsealy 1970

Treatment	Dose lb/ac	Yield tons/ac	No. onions /ft^2	Assessments 3 July 1970		Poa annua No./10ft^2
				Crop	Weeds	
Aziprotryne	2.0	15.7	5.9	9.5	8.5	19
Ioxynil octanoate	0.625	12.7	5.5	9.0	8.3	31
Dinoseb acetate	2.4	13.9	5.2	9.0	9.0	26
VCS-438	2.0	12.8	5.7	9.6	8.6	4
VCS-438	4.0	11.7	5.1	9.1	8.5	0
PP 493	0.5	10.4	5.1	7.1	8.3	15
S.E. of treatment mean(df=15)		1.31	0.28			

Assessments made nine days after application of treatments. Rating scale as in Table 2.

Table 4

Effect of treatments applied pre-harvest on crop and weeds, Kinsealy 1970

Treatment	Dose lb/ac	Yield tons/ac	No. onions /ft^2	Assessments 28 July 1970		% weed kill 16 September 1970		
				Crop	Weeds	P.a.	S.v.	S.o.
Chlorpropham	2.0	13.2	4.3	9.5	9.1	79	0	0
Aziprotryne	2.0	14.7	4.7	9.6	9.0	66	92	100
Simazine	0.5	11.7	4.4	9.0	9.0	89	100	91
"	1.0	10.9	4.3	9.4	9.0	95	100	100
"	1.5	11.4	4.5	9.5	9.1	100	92	100
Aziprotryne + Simazine	2.0 0.5	11.0	4.8	8.9	9.0	100	100	100
Aziprotryne + Simazine	1.0 0.5	11.6	4.6	9.0	8.8	93	100	100
Control		12.7	4.3	9.1	9.0	0	0	0
S.E. of treatment mean(df=21)		1.05	0.28					
Weeds/10ft^2 in control plots						4.7	0.8	0.7

Rating scale as in Table 2. P.a. - Poa annua, S.v. - Senecio vulgaris, S.o. - Sonchus oleraceus

In the third experiment at Kinsealy, treatments were applied to a crop free of annual weeds in mid-July when the onions had commenced to bulb and were about 1 in. in diameter. Agropyron repens, which was distributed unevenly in the trial area, caused some weed competition.

There was no evidence of adverse crop effects with any treatment (table 4) when plant counts and crop assessments were taken two and seven weeks after spraying. Weed counts recorded immediately prior to harvesting in mid-September showed that all doses of simazine and mixtures of simazine/aziprotryne had given excellent control of the main species present viz. Poa annua, Senecio vulgaris and Sonchus oleraceus. S. vulgaris and S. oleraceus were very well controlled by aziprotryne at 2.0 lb but were resistant to chlorpropham at 2.0 lb/ac. The latter, however, gave better control of P. annua than aziprotryne.

DISCUSSION

The application of chlorbufam/pyrazon or propachlor with or without paraquat prior to crop emergence is now widely used in Ireland for early season weed control in drilled onions. However, these treatments normally only provide satisfactory control up to the early one leaf stage of the crop and handweeding and cultivation or further applications of chlorbufam/pyrazon or propachlor/chlorpropham mixtures are necessary to maintain crops in a weed-free condition. These residual mixtures are expensive and because of their lack of contact action require careful timing of application for successful weed control. The results of the work carried out in 1969 and 1970 indicate that there are a number of herbicides with useful contact activity which have possibilities for early and late post-emergence use in this crop

In these experiments, aziprotryne at 2.0 lb/ac was the most selective treatment tested and confirmed the promise shown in earlier investigations (Cassidy and Doherty 1968, Roberts and Hewson 1968). No crop injury occurred with this herbicide when applied at the 2 leaf and 3 - 4 leaf stages in 1969 or at the crook- 1 leaf, 4 - 5 leaf and pre-harvest stages in 1970. Damage and reduction in stand however, did occur at the crook - 1 leaf stage in 1969, even though the weather was dry and sunny for a number of days prior to and after spraying - conditions regarded as suitable for minimising the risk of crop injury with contact herbicides in onions. A possible reason for the inconsistency of these results is that in 1969 the trial area was treated with propachlor at 3.9 + chlorpropham at 2.0 lb/ac three days before aziprotryne and the other herbicides were applied and this may have increased the sensitivity of the onion seedlings to injury. The propachlor/chlorpropham mixture was not used in the 1970 experiments.

Aziprotryne gave satisfactory contact and residual control of a number of important weeds in both years. An exception, however, was Poa annua, a species which can often be very troublesome in onion crops. A new herbicide - VCS-438 - tested for the first time in 1970 gave excellent control of this weed even at an advanced stage of growth. VCS-438 at 2.0 lb/ac also showed good crop selectivity at all stages of application and merits further investigation as a post-emergence treatment for onions. Another new herbicide, CP 52665 at 1.5 lb/ac, which caused no crop injury when applied at the crook - 1 leaf stage, was also promising for Poa annua control on peat soils.

Although no adverse crop effects resulted from application of ioxynil octanoate at 0.625 lb/ac at the crook - 1 leaf stage in 1970, the results obtained in 1969 indicate that this herbicide can cause significant crop damage even at the 2 leaf stage. In both years, however, it was safe for application when the crop had three well developed leaves.

Only one year's experience with dinoseb-acetate was obtained and although promising it may not have adequate selectivity under less favourable weather conditions for application at the early 1 leaf stage.

From the limited investigations carried out with phenmedipham at 1.0 lb, nitrofen at 4.0 lb and PP 493 at 0.5 lb/ac, it would appear that none of these treatments have sufficient selectivity for post-emergence application in onions.

Weed-free conditions at harvest are important, particularly with the advent of mechanised harvesting. If an effective relatively cheap residual herbicide like simazine could be safely used eight to ten weeks before harvesting it would be of considerable benefit. However, the results of the experiment carried out in 1970 suggest that simazine, applied in mid-July at the bulbing stage, had a depressing effect on yield although no symptoms of crop injury were evident. As there was no correlation (Table 4) between yield depression and the dose of simazine applied, other factors may have been responsible for this effect and further investigation of simazine as a pre-harvest treatment is warranted.

Acknowledgements

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EVALUATION OF N-(1,1-DIMETHYLPROPYNYL)-3,5-DICHLOROBENZAMIDE (RH-315) FOR WEED CONTROL IN LETTUCE

H. A. Roberts and R. T. Hewson
National Vegetable Research Station, Wellesbourne, Warwick

Summary In field trials on a sandy loam, N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide (RH-315) at 1.5 lb/ac a.i. pre-emergence gave better weed control than chlorpropham 1 lb/ac or sulfallate 1.8 + chlorpropham 0.25 lb/ac. Best results were obtained under cool, moist conditions, when early post-emergence treatments were also effective. Lettuce emergence, yield and maturity were not adversely affected; with 3 lb/ac there were some early injury symptoms, similar to those produced by chlorpropham at 1 lb/ac. Good control of *Poa annua*, *Polygonum* spp., *Stellaria media*, *Urtica urens* and other annual weeds was obtained, but Compositae and *Anagallis arvensis* were highly tolerant. Under warm conditions in summer the effectiveness of RH-315 was reduced.

INTRODUCTION

The herbicidal properties of N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide have been described by de Sarjas & Perrot (1969). They showed that pre-emergence applications of 0.75 - 1.5 lb/ac would kill many grasses and broad-leaved weeds, but that species of Leguminosae and Compositae were tolerant. Among possible uses which were envisaged for RH-315 was the selective control of annual weeds in lettuce. Promising results on this crop have also been reported under irrigated conditions in California (Lavalleye *et al.*, 1969).

To determine the potential of RH-315 for selective weed control in drilled lettuce under British conditions, a series of field trials was conducted on a sandy loam (16% clay, 6% silt, 2% O.M.) at Wellesbourne in 1969-70; the response of a range of vegetable crops to pre-emergence application was also examined.

METHODS AND MATERIALS

To determine relative crop tolerance, single rows of thirteen vegetable crops were drilled in spring and RH-315 applied across them shortly after drilling at doses of 0.75, 1.5 and 3.0 lb/ac a.i., using a 75% w.p. formulation and a volume of 100 gal/ac. Crop injury was then assessed on a scale of 0 (no effect) to 10 (complete kill). This test was not replicated but was carried out twice, once in 1969 and once in 1970.

The trials with lettuce, cv. Borough Wonder, were of randomised block design with three replicates. Each plot contained five 9-ft rows 1 ft apart, with guards between, and the plants were later thinned to 1 ft apart in the rows. Pre-emergence treatments were applied shortly after drilling and comparison was made with two standard treatments, chlorpropham (40% e.c.) 1 lb/ac a.i. and sulfallate 1.8 lb +

chlorpropham 0.25 lb/ac a.i. (J.M.S. No. 6). Post-emergence treatments with RH-315 were also made in three of the trials. The treated plots were not weeded, but both hand-weeded and unweeded control plots were included. Doses are given as lb/ac a.i.

Weed control was assessed weekly on a scale of 0 (no effect) to 10 (complete kill), beginning as soon as the effects of treatment became visible and ending at the final harvest. The individual lettuce heads were cut as they became marketable, usually on three occasions over a period of 10 days. The numbers and weights of marketable lettuce are expressed as percentages of those on the weeded control plots and values significantly less are indicated by single (P = 0.05) or double (P = 0.01) asterisks.

RESULTS

Crop tolerance

The scores for injury of the different vegetable crops recorded in the two tests are shown in Table 1. In both, lettuce was clearly among the most tolerant of the crops. With 1.5 lb/ac there were negligible effects, although with 3.0 lb/ac there was some check to growth. The large-seeded legumes were also relatively tolerant; with these, injury took the form of stunting of individual plants while others remained unaffected. The remaining crops were all injured to an appreciable extent by 1.5 lb/ac and sometimes by 0.75 lb/ac.

Table 1

Response of vegetable crops to pre-emergence applications of RH-315

	Crop injury (0 = no effect; 10 = complete kill)					
	1969 lb/ac			1970 lb/ac		
	0.75	1.5	3.0	0.75	1.5	3.0
Radish	4	7	9	4	6	8
Cabbage	4	7	10	2	5	8
Turnip	6	9	10	3	5	8
Lettuce	0	2	4	0	0	4
Carrot	7	8	10	-	-	-
Parsley	0	4	7	2	5	6
Parsnip	3	3	8	2	4	5
Spinach	8	9	10	3	6	8
Red beet	4	6	9	4	7	8
Onion	5	5	9	4	6	8
Leek	3	6	8	5	7	9
Pea	0	2	3	1	1	3
Broad bean	0	2	0	0	4	6

Weed control

All the pre-emergence treatments made with RH-315 at 0.75, 1.5 and 3.0 lb/ac in the period March - May 1969 gave complete kill of Chenopodium album, Poa annua, Polygonum aviculare, P. convolvulus, Stellaria media and Urtica urens. A few plants only of Capsella bursa-pastoris survived at 0.75 lb/ac. There was only a partial kill of Fumaria officinalis, and except with 3 lb/ac where they remained small, the survivors grew and flowered normally. Small numbers of *Atriplex patula*, *Papaver dubium* and *P. rhoeas* were present, and there was some evidence of tolerance in these species. All treatments gave a partial kill of *Trifolium repens* but with 0.75 and 1.5 lb/ac the survivors recovered and made extensive growth; with 3.0 lb/ac they remained small.

Few Compositae were present in these trials, and none appeared to be affected by any RH-315 treatment. The species observed included *Cirsium vulgare*, *Gnaphalium uliginosum*, *Lapsana communis*, *Matricaria matricarioides*, *M. recutita*, *Onopordum acanthium*, *Sonchus asper*, *S. oleraceus*, *Senecio vulgaris*, *Taraxacum officinale* and *Tripleurospermum maritimum* ssp. *inodorum*. In addition, *Anagallis arvensis* was found to be strikingly tolerant, and plants grew and flowered normally even where 3.0 lb/ac had been applied.

Table 2

Weed control in four trials with drilled lettuce

Herbicide	(lb/ac)	Weed control (0 = no effect; 10 = complete kill)							
		Drilled 31st March		Drilled 14th April		Drilled 1st May		Drilled 13th May	
		Days after drilling		Days after drilling		Days after drilling		Days after drilling	
		44	85	30	84	35	75	34	66
Pre-emergence									
Chlorpropham	1.0	7.7	6.7	6.7	5.7	9.0	7.3	8.3	6.7
Sulfallate + chlorpropham	1.8 + 0.25	7.3	6.0	7.3	5.0	-	-	-	-
RH-315	0.75	7.3	5.7	8.3	6.3	8.7	7.7	9.2	8.7
"	1.5	8.0	7.3	8.7	9.0	9.3	9.0	9.2	8.7
"	3.0	9.0	8.8	9.0	9.2	9.5	9.7	9.3	9.2
Post-emergence									
RH-315	0.75	5.0	5.7	2.7	6.7	1.0	6.0	-	-
"	1.5	6.0	7.3	1.7	8.0	0.0	5.0	-	-
"	3.0	6.0	8.7	4.7	8.7	4.7	6.7	-	-
Rainfall in first 3 weeks after drilling (in.)		0.52'		1.64'		1.58		2.15	
Mean 4-in. soil temp. in 1st week after drilling (°C)		5.0		9.0		11.5		13.0	

' Includes one irrigation of 0.25 in.

Initial and final weed control scores for four trials drilled in Spring 1969 are shown in Table 2. In the first two, neither of the standard treatments gave weed control which remained at an acceptable level until harvest. The main survivors other than Compositae were *Fumaria officinalis*, *Trifolium repens* and *Chenopodium album*. RH-315 at 0.75 lb/ac was also inadequate, mainly because of recovery by *T. repens*. In the two later trials, this treatment gave a better result than chlorpropham 1 lb/ac. RH-315 at 1.5 lb/ac gave better weed control than the standard treatments in all four trials, with little difference between the initial and final scores. Except in the first, there was little additional benefit from increasing the dose to 3 lb/ac.

Post-emergence application of RH-315 in the first two trials, at the cotyledon and 1-true leaf stages respectively, gave final results closely similar to those of the comparable pre-emergence applications. In the third, the sprays were applied when the crop was in the 2-3-true leaf stage, and none gave acceptable control. *Capsella bursa-pastoris* in particular appeared tolerant and at harvest large plants of this species were present, together with *Trifolium repens*, *Fumaria officinalis* and some *Chenopodium album*.

A fifth trial was drilled on 6th June at the beginning of a hot spell (mean 4-in. soil temperature approximately 20°C). Although 0.25 in. irrigation was given shortly after application, weed control was not so good as in the previous four trials, especially with 0.75 lb/ac where appreciable numbers of *Chenopodium album* survived. RH-315 at 1.5 lb/ac, however, gave better control than chlorpropham 1 lb/ac (final scores 7.3 and 5.7 respectively). A similar result was obtained in 1970 under comparable conditions, with *Chenopodium album* again the main survivor. On lettuce drilled in late summer for over-wintering, pre-emergence treatments of RH-315 gave excellent control of weeds, mainly *Poa annua*, *Stellaria media* and *Veronica persica*, and observations in spring showed that at 1.5 lb/ac the control obtained with this herbicide was rather better than that with either chlorpropham or sulfallate + chlorpropham.

Effects on lettuce

None of the herbicide treatments affected the numbers of lettuce seedlings which emerged, except on a single occasion when RH-315 at 3.0 lb/ac caused a statistically-significant reduction of 10%. Chlorpropham at 1 lb/ac consistently caused slight stunting of the seedlings with characteristic injury symptoms, including diffuse chlorosis, roughening of the leaf surface and modification of leaf shape, but later growth was not affected. With RH-315 at 0.75 and 1.5 lb/ac pre-emergence there was no visible sign of injury; at 3.0 lb/ac there were consistent symptoms which closely resembled those caused by chlorpropham.

Table 3

Effects on yield in four trials with drilled lettuce cv. Borough Wonder

Herbicide	(lb/ac)	No. and wt. of marketable lettuce (% of hand-weeded control)							
		Drilled 31st March		Drilled 14th April		Drilled 1st May		Drilled 13th May	
		No.	wt.	No.	wt.	No.	wt.	No.	wt.
Pre-emergence									
Chlorpropham	1.0	84*	89	85	73*	95	97	89	103
Sulfallate + chlorpropham	1.8 + 0.25	97	94	53**	49**	-	-	-	-
RH-315	0.75	84*	87	94	90	104	100	109	123
"	1.5	100	103	94	95	121	132	91	96
"	3.0	97	105	88	78	112	117	93	106
Post-emergence									
RH-315	0.75	82*	84	102	94	36**	35**	-	-

		No. and wt. of marketable lettuce (% of hand-weeded control)							
Herbicide	(lb/ac)	Drilled 31st March		Drilled 14th April		Drilled 1st May		Drilled 13th May	
		No.	wt.	No.	wt.	No.	wt.	No.	wt.
RH-315	1.5	92	96	101	92	44**	44**	-	-
"	3.0	87	90	100	94	83	84	-	-
% marketable on weeded control		87		89		75		63	

The numbers and weights of marketable lettuce, as percentages of the values for the weeded controls, are shown in Table 3 for four of the trials. Few, if any, lettuce attained marketability on the unweeded control plots, where the weed densities were 15-32 plants/ft^2. There was no evidence of any significant reduction in number or weight of marketable lettuce as a direct effect of the herbicide, nor was maturity delayed. The reductions that did occur were the result of competition from surviving weeds. With the weed populations encountered in these trials, RH-315 was sufficiently effective at 1.5 lb/ac pre-emergence to give marketable yields equal to those from hand-weeded control plots.

DISCUSSION

The results of these trials support the data on RH-315 presented by de Sarjas & Perrot (1969). Lettuce was the most tolerant of the small-seeded vegetable crops examined (Table 1) and in none of the tests did 1.5 lb/ac applied either pre- or post-emergence, cause any direct reduction in marketable yield. Additional tests on cv. Great Lakes and cv. Imperial showed them to be no less tolerant than cv. Borough Wonder. With pre-emergence applications of 3.0 lb/ac there was some initial check; this was no greater than that brought about by chlorpropham at 1 lb/ac, however, and the symptoms caused by these two treatments were similar both in character and intensity. Lettuce thus appears to possess adequate tolerance to RH-315, and the data suggest that a dose of 1.5 lb/ac would have an approximately two-fold safety factor compared with the standard chlorpropham treatment.

The results also confirm the data given by de Sarjas & Perrot (1969) for the relative susceptibility of weed species to RH-315. All eleven Compositae which appeared in the trials were unaffected by 3.0 lb/ac, while Anagallis arvensis was also highly tolerant. Trifolium repens was usually partially killed but the survivors recovered, while Fumaria officinalis, Papaver dubium, P. rhoeas and Atriplex patula appeared to require more than 1.5 lb/ac pre-emergence for complete kill. The remaining species encountered, Capsella bursa-pastoris, Chenopodium album, Poa annua, Polygonum aviculare, P. convolvulus, Stellaria media and Urtica urens, were all killed by pre-emergence applications of 1.5 lb/ac made in spring.

The best weed control was obtained under relatively cool, moist conditions, and when these prevailed, early post-emergence application was as effective as pre-emergence application. In hotter weather later in the season RH-315 was appreciably less effective and Chenopodium album in particular survived treatment. This is in accord with other work which indicates that in hot, dry conditions the herbicidal effect of RH-315 is limited and of short duration (Connin et al., 1970; Yih, Swithenbank & McRae, 1970). It has been suggested that shallow incorporation will improve performance under these conditions (de Sarjas & Perrot, 1969).

It is generally accepted that the herbicides at present available for selective use in lettuce crops do not control a sufficiently wide range of weeds and are not sufficiently reliable, particularly under summer conditions. Although RH-315 kills many of the weed species which commonly occur in lettuce crops, notably Stellaria media, Urtica urens and Poa annua, the tolerance of Senecio vulgaris and other Compositae must constitute a serious disadvantage. The results of the present trials suggest that in favourable circumstances, RH-315 can give more complete and lasting weed control than either chlorpropham or sulfallate + chlorpropham. As with these two treatments, however, RH-315 is comparatively ineffective under summer conditions. Further work will be required in a wider range of situations to determine whether or not RH-315 possesses consistent advantages over the existing available treatments for weed control in lettuce. The question of persistence must also be taken into account. Tests at Wellesbourne (A. Walker, personal communication) have shown that at soil temperatures encountered from October to May there is little loss of activity. When RH-315 was applied to lettuce drilled at the end of March, more than 40% of the initial activity still remained at the time of harvest.

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WEED CONTROL EXPERIMENTS IN DIRECT DRILLED AND TRANSPLANTED LETTUCE IN NORTHERN IRELAND

S D Uprichard and D J Allott*
Horticultural Research Centre, Loughgall, Armagh, Northern Ireland

Summary Pre-planting applications of sulfallate, sulfallate + chlorpropham, chloroxuron, prometryne, haloxydine, RH-315 (N-1, 1-dimethylpropynyl-3, 5-dichlorobenzamide), and post-planting applications of RH-315 had no significant effect on the mean yield of transplanted lettuce. Direct drilled lettuce showed a more variable response to similar herbicide treatments. Chloroxuron and prometryne reduced both the number of germinated seedlings and the final crop yield. No other herbicide, however, affected the crop. Weed control with sulfallate and sulfallate + chlorpropham was unsatisfactory. All other herbicides gave satisfactory weed control. Pre-emergence applications of RH-315 gave better weed control than its post-emergence use.

INTRODUCTION

Chlorpropham is the only herbicide that has been generally recommended for weed control in lettuce (British Crop Protection Council 1968). However, its limited weed spectrum and crop tolerance have prompted investigations to determine more efficient methods of weed control in this crop. Much of the work carried out in Northern Ireland by Robinson (1962) and Allott (1964, 1968) concentrated on the use of herbicide combinations such as chlorpropham + diuron, chlorpropham + fenuron and chlorpropham + sulfallate. These treatments were only partially successful because in spite of improved weed control they caused some crop damage and there were differences in varietal susceptibility. The general need, therefore, for improved and safer herbicides for use in lettuce has been recognised for some time. The introduction in 1969 of two new herbicides RH-315 (Rohm and Haas 1969) and haloxydine (Plant Protection 1969) prompted a series of investigations at Loughgall to evaluate these materials in lettuce and to compare them with previously examined herbicides.

METHOD AND MATERIALS

Experiments were conducted on a medium loam soil using direct drilled lettuce (cv. Suzan), transplanted lettuce in the open (cv. Suzan) and transplanted lettuce under polythene tunnels (cv. Kwiek). All experiments were designed as randomised blocks with four replicates. Herbicides were applied with an Oxford Precision sprayer in a spray volume of 50 gals water/ac. All herbicide doses refer to lb a.i./ac. The transplanted lettuce were planted on a 72 in. wide bed with an interplant spacing of 9 in.^{2}. Under polythene a 36 in. wide bed was used and a plant spacing of 8 in.^{2}. The direct drilled crop was sown with a precision seeder with rows 12 in. apart on a 72 in. wide bed. It was eventually thinned to 9 in. in the row. In this experiment a seedling count was taken before thinning using a 1 ft^2 quadrat which was thrown at random three times on each plot. Results are presented as the mean count per 1 ft^2. Weed control was assessed by scores on a scale from 0 - 5 where 0 = weeds absent and 5 = weeds dominant. At harvest the total number of plants and their total weight in lb were recorded. Yields are presented as mean

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* The Civil Service Management Division, Management Services 2, Stormont, Belfast BT4 3SX

weight per plant (lb). Statistical significance is indicated by the standard error of the difference between two treatment means.

RESULTS

Experiment 1

This experiment was designed to assess the behaviour of RH-315 and haloxydine when used under polythene tunnels. Pre-planting treatments were applied on 23 March 1970 and the lettuce, which were at the 6 true leaf stage, were transplanted the same day. The post-planting treatment of RH-315 was applied on 8 April. At the time of planting the soil was in a moist condition. The polythene was not removed until harvest on 13 May except to apply the post-planting treatments. Weeds were scored seven weeks after planting.

Table 1

Effect on mean yield of pre and post-planting herbicides applied to transplanted lettuce (cv. Kwiek) under polythene tunnels

Herbicide	Dose lb/ac	Mean yield lb/plant	Mean weed score
Unsprayed control	-	0.37	2.25
prometryne (pre-planting)	1.0	0.34	1.50
RH-315 (pre-planting)	1.5	0.36	1.75
RH-315 (post-planting)	1.5	0.38	2.75
haloxydine (pre-planting)	1.0	0.35	1.25
SE of a difference		± 0.023	-
Variance within treatment means		NS	-
df error 12. CV% 9.29.			

Table 1 shows that none of the treatments significantly reduced crop yield. The principal weeds on this site were Senecio vulgaris, Capsella bursa-pastoris, Stellaria media, Veronica persica and Lamium purpureum. All treatments gave a satisfactory overall weed control compared to the unsprayed control, with the exception of the post-planting application of RH-315. The pre-planting application of this herbicide gave a good control of S. media, V. persica and L. purpureum but control of C. bursa-pastoris was only moderate and S. vulgaris was not controlled. Haloxydine gave an excellent control of all weeds with the exception of S. vulgaris and C. bursa-pastoris.

Experiment 2

This experiment was established to study the value of RH-315 and haloxydine compared to a range of herbicides which had previously shown promise in earlier work at Loughgall (Allott 1968). Except where otherwise stated, all treatments were applied to direct drilled lettuce immediately after drilling on 26 May 1970. The post-emergence application of RH-315 was applied when the lettuce were at the 3-4 true leaf stage, on 12 June. At the time of the post-emergence spraying seedlings of S. vulgaris, S. media and C. bursa-pastoris were present. The weather was hot and dry when the pre-emergence treatments were applied. These conditions prevailed for two weeks after the herbicide application. Heavy rain on 10 and 11 June resulted in high soil moisture and high relative humidity for the application of the post-emergence treatment. For the remainder of the experiment, until harvest on the 29 July, soil moisture remained high and growing conditions were good. The germination count was recorded on 24 June just before thinning and the weed score seven weeks after sowing.

Chloroxuron and prometryne significantly reduced the number of germinated seedlings and the final crop yield (Table 2). Sulfallate also reduced the number of seedlings but did not affect the ultimate crop yield. None of the other treatments had an adverse effect on the crop. Both pre- and post-emergence applications of RH-315 controlled S. media but not S. vulgaris or C. bursa-pastoris. Haloxydine gave a good control of S. media, partial control of C. bursa-pastoris but did not control S. vulgaris.

Table 2

Effect on mean yield of pre and post-emergence herbicides applied to direct drilled lettuce (cv. Suzan)

Herbicide	Dose lb/ac	Seedling count/1 ft^2	Mean yield lb/plant	Mean weed score
Unsprayed control	-	8.08	0.57	4.50
sulfallate	3.0	6.58	0.56	4.50
sulfallate	3.0	9.00	0.60	3.50
+ chlorpropham	0.5			
chloroxuron	3.0	2.50	0.45	1.50
prometryne	0.75	3.08	0.45	2.25
RH-315	1.5	7.33	0.64	2.75
RH-315 (post-emergence)	1.5	8.00	0.66	2.00
haloxydine	1.0	7.42	0.68	1.75
SE of a difference		± 1.173	± 0.055	-
Variance within treatment means		***	**	-
df error 21				
CV%		25.54	13.52	

Experiment 3

Pre-planting herbicides were applied on 8 April 1970. The post-planting treatment was applied on 21 April. High soil moisture and good growing conditions prevailed for two weeks following the treatment applications. The main weeds present on this site were S. vulgaris, S. media, C. bursa-pastoris, L. purpureum, Chenopodium album, V. persica and Polygonum aviculare. Weed scores were recorded seven weeks after planting.

Table 3 shows that no treatment significantly reduced crop yield. All treatments, except sulfallate, reduced the weed stand compared to the unsprayed control. RH-315 gave good control of S. media, L. purpureum, P. aviculare and V. persica, partial control of C. bursa-pastoris and C. album poor control of S. vulgaris. Haloxydine gave a good control of most weeds present, but only partially controlled P. aviculare and C. bursa-pastoris and failed to control S. vulgaris.

Table 3

Effect on mean yield of pre- and post-planting herbicides applied to transplanted lettuce (cv. Suzan)

Herbicide	Dose lb/ac	Mean yield lb/plant	Mean weed score
Unsprayed control	-	0.50	4.00
sulfallate	3.0	0.51	4.00
sulfallate + chlorpropham	3.0 1.0	0.53	2.75
chloroxuron	5.0	0.48	1.75
prometryne	1.0	0.49	2.50
RH-315	1.5	0.48	1.50
RH-315 (post-planting)	1.5	0.53	2.00
haloxydine	1.0	0.47	1.50
SE of a difference		± 0.041	-
Variance within treatment means		NS	-
df error 21 CV% 11.50			

DISCUSSION

Experiments 1 and 3 indicate that several herbicides, in addition to chlorpropham, merit further investigation for weed control in transplanted lettuce. However, in direct drilled lettuce, Experiment 2 suggests that chloroxuron and prometryne are unsatisfactory but that RH-315 and haloxydine are both highly selective and must merit more intensive investigation. Whilst the tolerance of direct drilled and transplanted lettuce to RH-315 and haloxydine was undoubtedly demonstrated by these experiments, more information is required with respect to the optimum times for application and to varietal susceptibility. Weed control with RH-315 would seem to be dependent on cool moist soil conditions during and after spraying (Rohm and Haas 1969). In Experiment 2 weed control was not as efficient as in Experiment 3. This can be attributed to a period of hot dry weather following spraying in the former whilst in the latter treatment applications were followed by cooler damp conditions leading to lower soil temperatures. Drier conditions which prevailed under the tunnels, however, did not reduce weed control suggesting that low soil temperatures, which prevailed in experiments 1 and 3, are the most important factor. This conclusion is further supported by Walker (1969) who found a more rapid breakdown of RH-315 when soil temperature exceeded 13°C. During the Loughgall trials soil temperature only exceeded this value during May and June, hence the less efficient weed control in Experiment 2 during these months. Haloxydine gave good overall weed control in all experiments and unlike RH-315, did not appear to be affected by variations in soil moisture and temperature. This is consistent with research carried out by workers in Canada (Plant Protection 1969). While both RH-315 and haloxydine failed to control S. vulgaris and gave only moderate control of C. bursa-pastoris, the presence of these weeds did not present any competition problems in this series of experiments at Loughgall. In spite of the continued tolerance of Compositae spp, the overall weed spectrum of both these herbicides is wider than other materials used in lettuce and they could, therefore, be a valuable asset to weed control in this crop. The use of chloroxuron in transplanted lettuce must merit further investigation, as this material has also a wider weed spectrum than the traditional herbicide chlorpropham. The addition of sulfallate to chlorpropham, in an effort to widen the weed spectrum of the latter, was not successful. The evidence indicates that this herbicide combination is unlikely to have a future for weed control in lettuce in Northern Ireland.

Acknowledgements

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EVALUATION OF HERBICIDES IN DRILLED LETTUCE ON PEAT SOIL

F. S. MacNaeidhe and J. C. Cassidy[1]

Peatland Research Station, Lullymore, Co. Kildare, Ireland.

Summary In American crisp lettuce, grown on peat soil, pre-emergence application of haloxydine at 0.5 and 1.0 lb or 0.5 lb in combination with chlorpropham 1.0 lb or RH315(N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide) 1.0 lb gave highly satisfactory weed control. Haloxydine was also effective as an early post-emergence treatment. A dose of 1.0 lb/ac caused crop damage but 0.5 lb showed no adverse effects at either stage of application.

A high degree of selectivity was shown by RH315 both as a pre-emergence and post-emergence treatment, at doses up to 3.0 lb/ac. Weed control was more effective with pre-emergence application. Results with chloroxuron, aziprotryne and chlorpropham are also included.

INTRODUCTION

American crisp lettuce is a recent introduction to Ireland. Trials have shown that peat soils are particularly suited for its production. However, one of the main problems, especially with drilled crops, is severe weed competition. Lettuce is highly sensitive to most herbicides as shown by its frequent use as an indicator in bioassay systems. The 1968 edition of the Weed Control Handbook recommends only one herbicide viz. chlorpropham for use in drilled and transplanted lettuce crops. While chlorpropham can give moderately good results where only susceptible weed species occur, there is need for alternative herbicides capable of controlling a wider weed spectrum and which can be used both pre- and post-crop emergence.

METHOD AND MATERIALS

All experiments were conducted at Lullymore Peatland Research Station on a soil derived from fen peat. A randomised block design replicated four times with a standard plot size of 5 yd x 2 yd was used. Crops were drilled with a hand operated seeder in 18 in. rows at 1.25 lb of seed per acre and plants were thinned to 18 in. apart in the row at the 4 - 5 leaf stage.

Treatments were applied at a volume of 40 gal/ac using a pressure retaining knapsack sprayer. In the 1969 experiment plant density was assessed from counts within five one foot sections taken at random in each of three centre crop rows per

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[1] Present address : Kinsealy Research Centre, Dublin, 5., Ireland.

plot. Weeds were counted in the entire plot area in the 1970 experiments. At least two visual assessments of treatment effect on crop and weeds were made in all cases. The total marketable heads in each plot were recorded at harvest. All doses are given as lb/ac active ingredient.

RESULTS

In the experiments carried out in 1969, pre-emergence treatments were applied 8 days after sowing, 2 days before the crop emerged. Post-emergence application of RH315, at 1.0 lb/ac was made at the 4 - 5 leaf stage of the lettuce. Treatments and results are given in Table 1.

Table 1

Effect of herbicide treatments on crop and weeds. Lettuce 1969

(C.V. Great Lakes 659, drilled May 15).

Treatment	Dose lb/ac	Stage of Application	Mean Plant stand (10 ft row)	Assessments(June26)	
				Crop vigour	Weeds
Chlorpropham	3.0	pre-emergence	38	8.8	7.6
RH315	1.0	" "	33	9.2	8.0
RH315	1.0	4 - 5 leaves	30	9.0	6.6
Chloroxuron	10.0	pre-emergence	16	8.4	8.4
Chloroxuron	5.0	"	22	9.0	7.6
Aziprotryne	2.0	"	19	8.0	8.6
S.E of treatment mean (df= 21)			3.6		

Rating scale : Crop vigour: 0(complete kill) - 10 (no damage)
Weeds : 0(dense cover of weeds - 10(no weeds).

The trial site had been used for industrial peat harvesting up to 1967 and as a result weed population was low and erratically distributed over the area. Senecio vulgaris, Poa annua, Stellaria media and Rumex acetosella were the only species which occurred.

Chloroxuron at 5.0 and 10.0 lb and aziprotryne at 2.0 lb/ac caused a significant reduction in plant stand but had no effect on the vigour of surviving lettuce plants when assessed 2 and 5 weeks after emergence. RH315 at 1.0 lb/ac showed good selectivity as a pre- and post-emergence treatment and plant stand was not significantly reduced compared to the standard treatment, chlorpropham at 3.0 lb/ac.

Most effective weed control was obtained in plots treated with chloroxuron at 10.0 lb and aziprotryne at 2.0 lb/ac. RH315 also gave satisfactory control particularly with pre-emergence application but Senecio vulgaris was resistant. This species was resistant to chlorpropham which also gave poor control of Poa annua.

In 1970, two experiments were carried out in which RH315 and halcxydine were the main herbicides examined for pre- and post-emergence application.

In the first experiment, pre-emergence treatments were applied 4 days after drilling under dry soil conditions. Weed density was low in the trial area. The main weed species present in order of prevalence were Rumex acetosella, Polygonum persicaria, Poa annua and Stellaria media.

Results are given in Table 2. All treatments showed a high degree of crop selectivity except for haloxydine at 1.0 lb/ac which caused a severe initial check to crop vigour. However, the crop recovered from this damage and no significant depression in the number of marketable heads occurred.

Table 2

Effect of pre-emergence treatments on crop and weeds. Lettuce, 1970

(C.V. Great Lakes 659, drilled June 6).

Treatment	Dose lb/ac	Assessments (July 7)		Mean no. of marketable heads per plot	% weed kill		
		crop	weeds		Poa annua	Rumex acetosella	Polygonum persicaria
RH315	1.0	9.0	6.1	18	72	44	90
RH315	2.0	9.8	8.2	18	95	77	77
RH315	3.0	10.0	9.0	23	97	90	98
Haloxydine + RH315	0.5 1.0	10.0	10.0	23	98	94	92
Haloxydine	0.5	9.3	9.0	18	91	86	82
Haloxydine	1.0	7.0	9.7	18	96	87	80
Haloxydine + Chlorpropham	0.5 1.0	8.8	10.0	23	99	83	91
Chlorpropham	3.0	9.5	9.0	21	87	92	90
Control (Untreated)		10.0	3.6	20	0	0	0
S.E. of treatment mean (df = 24)				2.85			
Weeds/10 yd^2 in control plots					93	51	50

Rating scale : Crop 10 (complete kill) - 0 (no damage)
Weeds 0 (dense cover of weeds) - 10 (no weeds).

All treatments gave good control of Polygonum persicaria. This species was particularly sensitive to RH315 and there was no significant difference in the degree of control between the 1.0 and 3.0 lb/ac doses. The lower dose was not sufficient to give adequate control of Rumex acetosella or Poa annua but these species were controlled satisfactorily at 2.0 and 3.0 lb/ac. Residual activity of RH315 was rather short lived and after a period of 4 weeks from application weeds had begun to germinate in plots treated with this herbicide irrespective of the dose applied.

Haloxydine at 0.5 and 1.0 lb/ac gave satisfactory control of all weed species present. When weed counts were taken there was little difference in the degree of control between either dose. Later observations showed, however, that the higher dose gave more prolonged control. Plots treated with haloxydine at 1.0 lb/ac were still essentially weed-free 11 weeks after application.

Chlorpropham 3.0 lb gave good control of Polygonum persicaria and Rumex acetosella but was less effective against Poa annua than haloxydine at 1.0 lb and RH315 at 2.0 lb/ac.

The most effective treatment in the trial was the combination of haloxydine at 0.5 lb and RH315 at 1.0 lb/ac. This treatment provided even longer residual control than haloxydine at 1.0 lb. Weed control with haloxydine at 0.5 lb + chlorpropham at 1.0 lb/ac was also highly satisfactory being only slightly less effective than the haloxydine/RH315 mixture.

In the post-emergence experiment, treatments were applied at the 1 true leaf stage of the lettuce, 2 weeks after the crop emerged.

Prior to emergence the entire trial area was sprayed with chlorpropham at 3.0 lb + paraquat at 0.5 lb/ac. As a result there were few weeds present when the post-emergence treatments were applied. These were mainly at the cotyledon - 1 rough leaf stage and *Poa annua* was the principal species. Treatments and results are given in Table 3.

Table 3

Effect of post-emergence treatments on crop and weeds. Lettuce, 1970

(C.V. Great Lakes 659. Drilled June 6).

Treatment	Dose lb/ac	Assessments July 14		Mean no. of marketable heads / plot	Mean no. of weeds/plot	% weed kill *Poa annua*
		crop	weeds			
RH315	1.00	9.0	6.5	14	73	33
RH315	2.00	9.7	5.7	15	55	48
Haloxydine	0.25	9.5	8.4	17	17	91
Haloxydine	0.50	9.7	10.0	15	13	93
Haloxydine	1.00	7.7	9.5	9	4	99
Control(untreated)		10.0	2.3	13	104	0
S.E. of treatment mean (df = 15)				1.15		

Rating scale : Crop 0(complete kill) - 10(no damage)
Weeds 0(dense cover of weeds) - 10 (no weeds).

Assessments taken 18 days after application of treatments showed no evidence of crop injury with RH315 at 1.0 and 2.0 lb/ac and haloxydine at 0.25 and 0.5 lb/ac. Haloxydine at 1.0 lb/ac however, reduced both crop vigour and stand and this is reflected in the lower number of marketable heads harvested as compared to other treatments.

Most effective weed control was obtained with haloxydine. Even the lowest dose used - 0.25 lb/ac provided good weed control up to harvesting. Control of *Poa annua* was poor with RH315 irrespective of the dose applied.

DISCUSSION

The use of pelleted seed and drilling to a stand has not progressed to the same extent in outdoor lettuce production as in a number of other vegetable crops, because of the lack of satisfactory herbicides. The results reported in this paper indicate that two experimental herbicides - RH315 and haloxydine look particularly promising for both pre- and post-emergence application in drilled lettuce on organic soils.

RH315 at doses up to 3.0 lb/ac applied pre-emergence and 2.0 lb/ac post-emergence at the early 1 true leaf stage caused no injury in American crisp type lettuce in trials on peat soil at Lullymore. This herbicide appeared to be more effective as a pre-emergence residual treatment, particularly against Poa annua. The failure of RH315 to control Senecio vulgaris, a problem weed of peat soils is a definite limitation but on the credit side it provided good control of Polygonum persicaria and Rumex acetosella, two other species which can be very prevalent on these soil types. The relatively short period of 4 weeks residual activity even at a dose of 3.0 lb/ac is another drawback to this material. Nevertheless, because of its high degree of selectivity it may be possible to overcome this by well timed repeated applications of RH315 during the growing period of the lettuce crop.

Indications from the 1970 experiments were that haloxydine has not as high a degree of selectivity as RH315. Damage occurred at a dose of 1.0 lb/ac with both pre- and post-emergence applications. However, since very effective weed control was obtained with haloxydine at 0.5 lb/ac pre-emergence and at doses as low as 0.25 lb/ac post-emergence without any symptoms of crop damage, the question of selectivity may not arise. Haloxydine has an advantage over RH315 in its greater residual activity and good contact properties.

The combinations of haloxydine at 0.5 lb + RH315 at 1.0 lb/ac and haloxydine at 0.5 lb + chlorpropham at 1.0 lb/ac, particularly the former, were also very promising both for effective weed control and safety to the crop. More information, however, is needed on the spectrum of weeds controlled individually by haloxydine and RH315 before the value of such combinations can be fully assessed.

Of the other materials tested only chlorpropham, the standard treatment, was selective. No damage occurred with this herbicide at a dose of 3.0 lb/ac, applied pre-emergence. Both aziprotryne at 2.0 lb/ac and chloroxuron at 5.0 lb/ac and 10.0 lb/ac caused severe reductions in plant stand.

While the results in this paper are only based on very preliminary investigations, they are sufficiently encouraging to predict that satisfactory chemical weed control programmes for lettuce grown on organic soils may be a reality in the not too distant future.

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CONTROL OF CARROT GROWTH AND SPLITTING USING DIMEXAN

W. D. Kerkham
Bos Chemicals Ltd., Gedney, Spalding, Lincs.

Summary During each of three years dimexan was applied at rates varying from 8.5 to 25.0 lb/ac a.i. to the foliage of carrots, harvest being at intervals of 0,2,4 and 6 weeks after treatment. With dense foliage of 18 in. height, 12.5 lb/ac was found to desiccate the tallest of the foliage leaving lower, sheltered foliage intact. Following the treatment there was a reduction of overall growth rate, and fewer large and split carrots were produced. Where there was sufficient protection of the shorter foliage by the taller foliage of larger carrots, treatment increased the yield of smaller carrots.

INTRODUCTION

For canning and other methods of prepacking processors require carrots that are uniform in size, shape and colour to be delivered from July to early the following year. In order to supply the required product growers are tending to specialize in the production of small carrots. They are using improved cultivars and seed sowing techniques but, without accurate weather forecasting, are unable to maintain a continuous supply of small carrots without excessive yields of oversized roots. There is little demand for carrots greater than 1¼ in. and less than 2 in. diameter.

A major problem in the production of large carrots, i.e. over 2 in. diameter, is the tendency to splitting particularly during periods of rapid growth.

Dimexan (dimethyl dixanthogene disulphide) has been used since 1959 as a contact herbicide for application prior to crop emergence (Feekes, 1962), and since 1963 as a crop desiccant (Soest, 1968 S.N.Ui.F, 1964).

Following the first observation trial (Kerkham, 1968) of the effect of dimexan on carrot foliage and roots, an investigation was started to define the relationship of rate of application with level of defoliation, growth and splitting of carrots. Tests were to be made of rate of growth and splitting at intervals up to six weeks after treatment; also of flavour of treated and untreated produce. The programme was expanded in 1969 to include half acre semi-commercial treatments and in 1970 to include crops with little foliage such as Amsterdam forcing types.

METHODS AND MATERIALS

Application rate is expressed as the equivalent of lb/ac a.i. of dimexan in approximately 40 gal water. All trials were in commercially grown crops of Chantenay type on sand or loamy sand soils. Materials were applied using an Azo butane plot sprayer with a 2m boom, fine Birchmeier nozzles and 1.5 kg/sq.cm pressure. Treatments were replicated three times in 1968, four times in 1969 and six times in 1970. Samples were all carrots from 2, 4 or 6 yd of row, depending on the plant density, but constant at any site. They were pulled by hand, topped and graded or canned within 24 hours for taint testing. Grading was a measure of the diameter of the carrots at their widest part using parallel bar riddles with bars spaced at ½ in., ¾ in., 1 in., 1¼., 1½ in. and 2 in.

Taint tests were undertaken by the Fruit and Vegetable Preservation Research Association.

The commercial samples were from adjacent 5 ac treated and untreated strips. The soil was very high in organic matter, the cultivar a Chantenay red cored, stumprooted selection and the foliage 18 in. in height and dense at treatment. Ten samples were taken, each being the produce from 10 ft length of one pair of twin rows at 30 in. centres.

RESULTS

Taint tests Samples were taken from a site 17 days after treatment with 12.5 lb/ac dimexan in October 1968. Treatment during 1969 was at the rate of 16.5 lb/ac. Samples were taken from three sites, 14 days after treatment and from one site 72 days after treatment. No taints were detected in any of the samples.

Effect on foliage During 1968 a crop with dense foliage 16 to 18 in. in height was treated with dimexan at three rates. On visual assessment 17 and 31 days after treatment it was found that:

a) With 25 lb/ac all but the lowest leaves were completely desiccated, the crowns of the carrots were discoloured by light and were visible from above the foliage. There was an increase in the rate of growth of fresh foliage as compared with untreated carrots.

b) With 8.5 or 16.5 lb/ac one or two of the tallest fronds of each plant were completely desiccated, leaving one or two with over 50% of each leaf sound and two or three leaves slightly spotted or unaffected. There was no change in colour of the carrot crowns which were sheltered by the surviving foliage and little or no increase in growth of fresh leaves.

In all further trials and commercial use, where there has been dense foliage of 18 in. height, 12.5 lb/ac of dimexan has left most foliage intact. This has also been the case with shorter foliage that has grown slowly prior to treatment but for short lush Chantenay foliage the appropriate dose rate has been 10.0 lb/ac. With Amsterdam forcing type carrots too much foliage has been destroyed where more than 8.5 lb/ac was applied.

During 1969, 24 different cultivars of Chantenay, Danvers etc. were treated, at one site, with 8.5 lb/ac of dimexan. The effect on the foliage of each cultivar was similar.

Effect on rate of growth

Table 1

Total yield (lb/plot) at intervals after application of four rates of dimexan (1969)

Dose rate dimexan lb a.i./ac	Intervals after application (days) 0	14	28	42
0	32.5	50.6	83.5	119.0
8.5		44.0	62.8	90.3
12.5		43.3	67.9	88.8
16.5		43.9	65.1	89.0
21.0		46.5	60.3	86.2

L.S.D. 8.1 (P = 0.05), 11.0 (P = 0.01)

In Table 1 it can be seen that dimexan treatment reduced the rate of growth of carrots but that there was no significant difference between the effects of the four chemical treatments. The effects continued for at least 42 days.

At some sites, 14 days after treatment, it was found that 21.0 lb/ac had a greater effect than did 8.5 or 12.5 lb/ac, but these differences tended to be small at 42 days after treatment.

Table 2

Graded weights of carrots at three sites, at treatment and four weeks after treatment lb/plot

Year and Dose rate lb a.i./ac	Treatment to lift (days)	Size grades in in. diameter under ¾	¾ - 1	1 - 1¼	1¼ - 1½	over 1½	Total
1968	0	most carrots ¾ - 1¼ in.					
0	31	2.0	6.75	11.5	25.5		45.5
16.5	31	2.5	9.75	18.25	11.75		42.25
1969	0	11.6	9.4	10.1	1.4	-	32.5
0	28	5.6	9.0	23.1	16.0	29.7	83.5
12.5	28	6.8	10.5	21.5	11.8	17.2	67.9
1970	0	17.6	10.9	3.9	-	-	32.5
0	28	11.1	15.8	12.7	3.9	0.75	44.4
12.5	28	11.7	13.7	5.9	3.6	0.29	35.3

The figures in Table 2 show:

a) The overall rate of growth of an untreated crop during four weeks varied from site to site; this was largely due to differing weather conditions.

b) Where there was dense foliage sheltering the foliage of smaller carrots in the 1968 trial the yield of $\frac{3}{4} - 1\frac{1}{4}$ in. carrots increased due to treatment, but where in the 1969 and 1970 trials there was not so dense a canopy, the smaller canning grades were not increased by treatment.
c) In order to avoid too many carrots going over 1 in. size it was necessary to treat when most carrots were $\frac{1}{2} - \frac{3}{4}$ in. as in 1970.
d) The dose rates were low enough not to cause excessive defoliation and subsequent excessive regrowth. There was not a complete control of root growth.

<u>Effect on carrot splitting</u>

Table 3

Number of split carrots at intervals after treatment (1969)

Dose rate dimexan lb a.i./ac	Mean no. of splits/plot 2 weeks	4 weeks	6 weeks	No. of splits per 100 lb carrots 2 weeks	4 weeks	6 weeks
0	10.3	87.5	126.3	20.8	104.6	106.7
12.5	7.3	37.5	55.0	17.4	51.2	62.9

Treatment L.S.D. 16.4 ($P = 0.05$) 22.3 ($P = 0.01$) 13.5 ($P = 0.05$) 18.3 ($P = 0.01$)

It can be seen in Table 3 that dimexan treatment reduced carrot splitting by more than 50%. The major development of splitting was from two to four weeks after treatment and control continued until at least six weeks after treatment.

Effect of dimexan at one commercial site 1969. Sampling was carried out two weeks after treatment.

Table 4

Yield as sampled from treated and untreated areas of the field

	Splits	Other defects	grades as in. diam. $\frac{3}{4}$	$\frac{3}{4} - 1\frac{1}{4}$.	$1\frac{1}{4} - 2$.	Over 2.	Market total	Overall total
With dimexan								
tons/ac	0.17	0.83	0.39	7.63	6.09	-	13.73	15.11
% total yield	1.2						90.7	
% market. yield				55.6	44.4			
Without dimexan								
tons/ac	2.67	0.77	0.23	5.97	8.41	0.23	14.63	18.33
% total yield	14.6						79.8	
% market. yield				40.8	57.5	1.7		

The figures in Table 4 were confirmed by the commercial grading of all carrots from $1\frac{1}{3}$ ac treated and not treated, also by samples out of bulk loads from the site. It can be seen that, on this site where foliage was 18 - 20 in. height and very dense, dimexan treatment:
i) reduced overall growth and total marketable yield two weeks after treatment
ii) increased the yield of $\frac{3}{4} - 1\frac{1}{4}$ in. diam. carrots i.e. those suitable for prepacking

iii) controlled splitting
iv) reduced the development of carrots larger than $1\frac{1}{4}$ in. diameter.

The commercial crop was lifted with a harvester which pulled the carrots by the foliage.

DISCUSSION

Taint tests. The absence of taint in dimexan treated carrots is in common with tests on peas. Further tests are in progress with carrots treated during 1970.

Effect on foliage. Complete crop defoliation is thought to encourage the rapid growth of fresh foliage, to lead to discolouration of carrot crowns and to the loss of colour and toughening of the carrot core. Too great a removal of foliage would also mean that growers could not lift carrots by the foliage if they wished to do so. From the trials and commercial use, it seems that the application of dimexan at 12.5 lb/ac desiccates only the tallest foliage of dense crops, approximately 18 in. in height. The rate may be raised for very dense foliage that has grown slowly or it may be lowered for soft, less dense or short foliage. Where plants stand independent of each other, in order to avoid spray material running down the stem, the water volume should be reduced to 20 gal/ac.

Effect on rate of growth and splitting. The rate of growth, the proportion of small carrots and the degree of splitting are largely determined by the genetical make-up of the plants, their spacial arrangement in the soil, the soil environment and the weather. The results reported show that dimexan may be used to reduce growth and splitting for at least six weeks after application. With dense crops 18 in. high dimexan at 12.5 lb/ac has always been found to give a good control; at 8.5 lb/ac the initial effect has sometimes been small. The greater defoliation with 21 lb/ac has on occasion been followed by an increase in splitting by six weeks after treatment. The conclusion is that 12.5 lb/ac of dimexan is a safe dose suitable for application to a wide range of crops.

From the data presented in this paper which is supported by data from further replicated and field trials, it is concluded that, where treatment is followed by conditions conducive to growth, as compared with the untreated crop:
i) overall growth rate will be reduced
ii) splitting will be reduced
iii) the production of large carrots will be reduced
iv) the proportion of small carrots will be increased by treatment; the yield of small carrots will be increased (assuming very small carrots are present at treatment) if the foliage of very small carrots is protected, by the taller foliage of larger carrots, from desiccation with dimexan.

Timing application. Dimexan is seen to have slowed growth of carrots. The treatment is not known to have stopped growth. It follows that to avoid the production of large or split carrots, application should be made before a significant weight of them is present and to obtain the maximum yield of small carrots, application should be made while there are a number of carrots which are smaller than the required size.

Acknowledgments

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INFLUENCE OF CHLORMEQUAT ON TRANSPIRATION AND DRY MATTER PRODUCTION OF CEREALS

U. Wünsche

Department of Plant Husbandry, Agricultural College of Sweden,
S-750 07 Uppsala, Sweden

Summary The influence of chlormequat (2-chloroethyltrimethyl ammonium chloride) on transpiration and dry matter production was studied in greenhouse experiments with wheat at three soil moisture levels and with wheat, barley, oats and rye at one (high) soil moisture level. Chlormequat reduced transpiration of wheat (at all soil moisture levels), barley and oats, but the influence on rye was very small. Total dry matter production and grain yield was reduced in wheat and oats and increased in barley. There was no significant influence on rye in this respect. Chlormequat increased the transpiration coefficient for wheat, barley and oats but not for rye.

INTRODUCTION

A yield increasing effect of 2-chloroethyltrimethyl ammonium chloride (chlormequat or CCC) is often demonstrated in field experiments with cereal cultivars with poor standing powers. In many cases, however, this is an indirect effect, depending on the ability of the growth regulator to increase the resistance against lodging, rather than a direct physiological effect on the yielding capacity. In trials with stiff-strawed cultivars or in other cases where no lodging occurs in untreated plots, the results are often conflicting. In these cases there are reports both of yield increases as well as yield decreases after treatment with chlormequat. (For a review of this literature see Wünsche, 1970). In general it is not possible to determine from published data whether there is a correlation between the chlormequat effect on grain yield and any other factor besides lodging.

One factor which might have an influence is the soil water content. Since there are reports in the literature that chlormequat increases drought resistance (see e.g. Halevy & Kessler, 1963; Kharanyan, 1967; Kaul, 1968; Farah, 1969; Uskov & Pyatygin, 1969) it seemed to be of interest to study in greater detail the influence of this growth regulator on the water relationship of the plant and on the dry matter production at various soil moisture levels. The aim of the investigations presented here has also been to compare the effect of chlormequat on different species of cereals.

MATERIAL AND METHODS

The plants were grown in a greenhouse in 3 litre plastic pots containing an organogenic soil. Three weeks after sowing they were thinned, six plants of a uniform size being left in each pot. They were treated with various amounts of chlormequat in 250 ml of water applied to the soil (0, 10^{-3} M and 10^{-2} M a.i.). Each treatment consisted of four 6-plant replicates.

The plants were fertilized once every week by adding 250 ml of water containing 2 g of a mixed fertilizer per litre. The fertilizer contained 17.5 % N, 4.6 % P and 9.2 % K.

Water loss was determined by weighing each pot daily to the nearest 5 g. Initially water was added to each pot after weighing to bring it back to a predetermined weight corresponding to a certain per cent of soil moisture. The loss of water by evaporation from the soil was estimated by the weight loss of pots without plants.

The temperature and humidity in the greenhouse were controlled to some extent, the day temperature varying between 20° and 30° C, the night temperature between 12° and 20° and the relative humidity between 40 and 90 %. In order to compensate for environmental differences the pots were circulated around the greenhouse bench.

The plants were harvested when all plants had ripened and the water loss was reduced to approximately the amount of evaporation. For oats this stage was not reached, due to abundant development of late tillers.

Experiment 1: Spring wheat, cv. Svenno. The evapotranspiration and dry matter production were compared at three soil moisture levels. The highest soil moisture content (immediately after watering) corresponded to approximately the following values:

	Water % by vol.	pF
High soil moisture level	65	1.2
Low soil moisture level I	40	2.5
Low soil moisture level II	35	3.0

At the two low soil moisture levels the plants were watered only every second day.

Experiment 2: Evapotranspiration and dry matter production was compared in spring wheat (Ring), barley (Ingrid), oats (Sol II) and rye (Petkus) at one soil moisture level corresponding to the high level in exp. 1.

RESULTS

The influence of chlormequat on evapotranspiration is shown in Figs. 1 and 2. In order to simplify the graphs only weight losses for untreated pots and pots treated with the highest CCC-concentrations are plotted. With a few exceptions, the values for the pots treated with the intermediate concentrations fall between the two curves given. Chlormequat reduced evapotranspiration of spring wheat (at all the three soil moisture levels) as well as that of barley and oats during the first 9 weeks after treatment. The influence was least on rye.

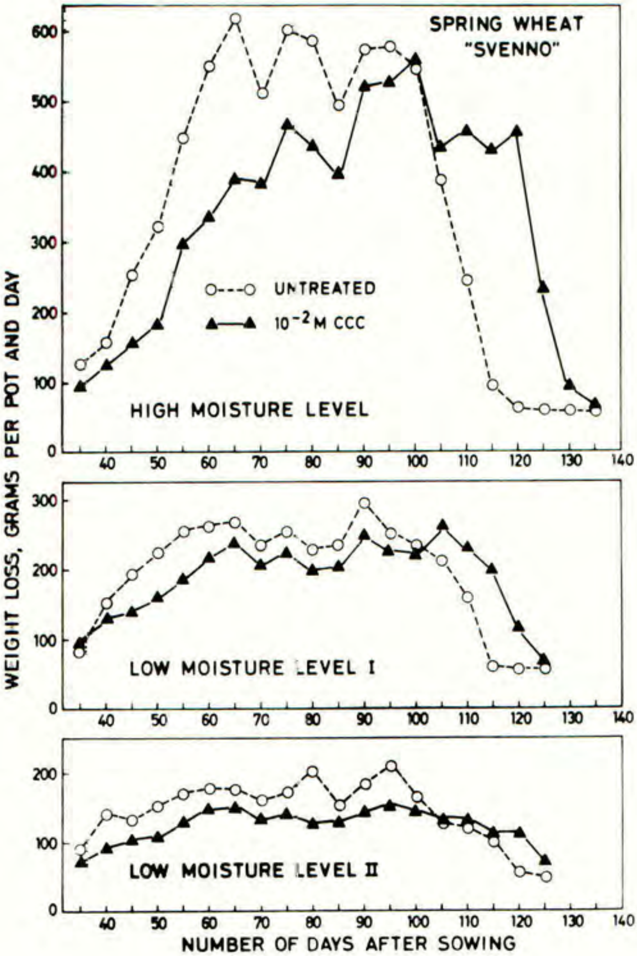

Fig. 1. Influence of chlormequat on evapotranspiration of spring wheat, cf. Svenno at three soil moisture levels. Each point in the diagrams represents the mean value of 5 days weight losses.

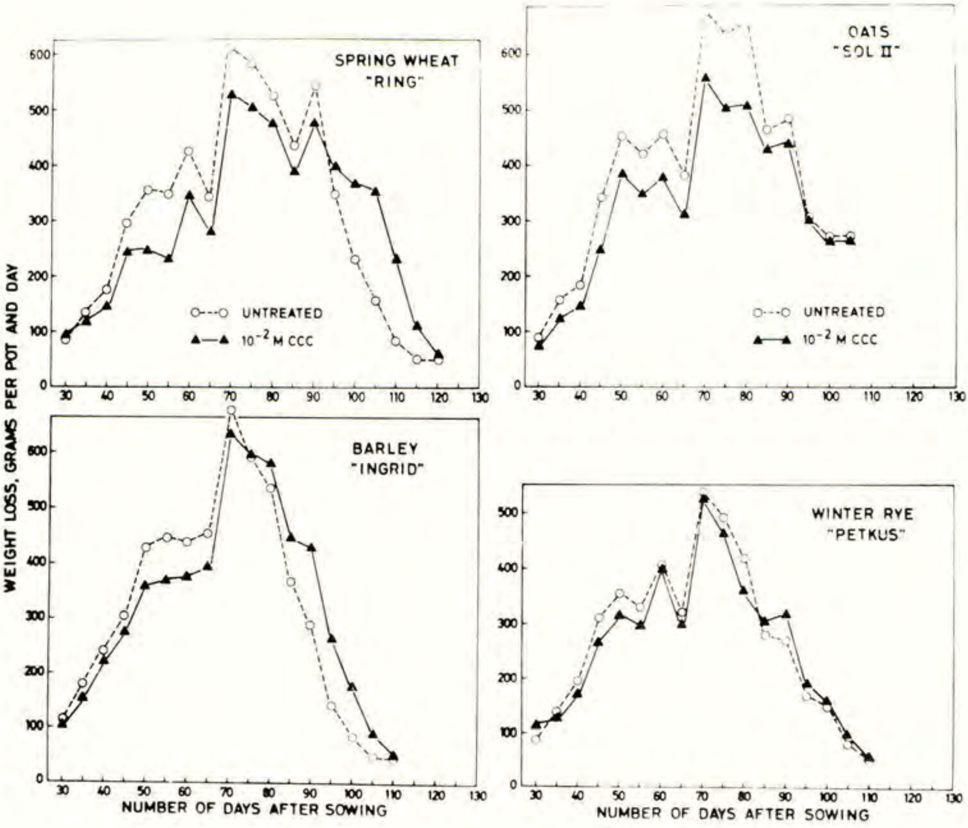

Fig. 2. Influence of chlormequat on evapotranspiration of spring wheat, barley, oats and spring rye. Each point in the diagrams represents the mean value of 5 days weight losses.

The transpiration rate decreased more slowly for treated than for untreated plants due to later ripening of the former (cf. Wünsche, 1970).

Total dry matter production and grain yield was reduced by chlormequat in wheat and oats whereas the yield was increased in barley. The influence in this respect was again least on rye (Table 1 and 2). Chlormequat increased the transpiration coefficient (amount of water used per gram of dry matter produced) for wheat, barley and oats but not for rye. The amount of water used to produce 1 g of grain was increased for wheat. For the other species there was no significant influence in this respect.

Table 1

Influence of chlormequat on plant length, grain yield of spring wheat, cv. Svenno at three soil moisture levels

Treatment	Plant length		Grain yield		Used amounts of water per produced amounts of			
					Grain		Plant dry weight	
	cm	rel.	g	rel.	g	rel.	g	rel.
	High moisture level							
Untreated	103	100	59.9	100	556	100	225	100
10^{-3}M CCC	69	67	45.8	76	680	122	227	101
10^{-2}M CCC	62	60	49.0	82	654	118	244	108
	Low moisture level I							
Untreated	82	100	39.1	100	404	100	195	100
10^{-3}M CCC	60	73	30.5	78	537	133	206	106
10^{-2}M CCC	57	70	31.0	79	490	121	216	111
	Low moisture level II							
Untreated	75	100	29.4	100	392	100	183	100
10^{-3}M CCC	55	73	24.6	83	445	114	158	86
10^{-2}M CCC	50	67	22.8	77	404	103	186	101

Table 2

Influence of chlormequat on plant length, grain yield and transpiration coefficient of spring wheat, barley, oats and spring rye

Treatment	Plant length		Grain yield		Used amounts of water per produced amounts of			
					Grain		Plant dry weight	
	cm	rel.	g	rel.	g	rel.	g	rel.
	Spring Wheat, cv. Ring							
Untreated	105	100	50.7	100	435	100	212	100
10^{-3}M CCC	82	78	39.3	78	574	131	252	119
10^{-2}M CCC	70	67	32.7	64	705	162	277	131
	Barley, cv. Ingrid							
Untreated	98	100	44.9	100	481	100	212	100
10^{-3}M CCC	93	95	47.6	106	490	102	224	106
10^{-2}M CCC	90	92	49.6	110	451	94	210	99
	Oats, cv. Sol II							
Untreated	133	100	44.8	100	543	100	245	100
10^{-3}M CCC	130	98	38.8	87	561	103	225	92
10^{-2}M CCC	121	91	36.4	81	551	101	219	89
	Spring Rye, cv. Petkus							
Untreated	140	100	37.6	100	472	100	202	100
10^{-3}M CCC	131	94	40.6	108	435	92	202	100
10^{-2}M CCC	126	90	39.5	105	443	94	206	102

DISCUSSION

The results confirm earlier findings by the author (Wünsche 1970) that chlormequat influences the transpiration rate of wheat. The fact that the transpiration is reduced only during earlier growth stages and that the treated plants will continue their water uptake over a longer period than untreated plants may explain why there are contradictory reports in the literature. Reduced transpiration is shown by Sivadjian (1967) and Farah (1969). Tolbert (1960) reported that wheat seedlings retarded by chlormequat showed no reduction in transpiration whereas Zemanek (1967) reported an increased transpiration rate of leaves from treated plants.

In spite of the influence on transpiration chlormequat did not improve the water economy in the dry-matter production of wheat. On the contrary the plants treated with the highest concentrations in Exp. 2 used about sixty per cent more water to produce the same amount of grain and about thirty per cent more in the total dry matter production.

In all cases chlormequat reduced the grain yield of wheat as well as the total dry matter production and there seems to be no correlation between the soil moisture content and the influence of chlormequat on the yield. Thus, the explanation why chlormequat increases yield in some cases and reduces it in others, is not to be found in differences in the amount of available soil water.

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FURTHER DEVELOPMENT OF SUCCINIC ACID 2,2-DIMETHYL HYDRAZIDE (B995) AS A GROWTH REGULANT IN POTATOES AND BRUSSELS SPROUTS

D. Laycock and D. Tyson
CIBA Agrochemicals Limited, Whittlesford, Cambridge

Summary Trials in 1969 showed yield increases in Brussels sprouts from treatment with 0.85 lb/ac succinic acid 2,2-dimethyl hydrazide (B995) on responsive cultivars if harvested early in the season and an increase in yield of canning sized tubers from responsive potato cultivars, in particular Maris Peer, harvested 25 to 31 days after treatment with 1.7 lb/ac B995.

INTRODUCTION

Preliminary trials reported in 1968 (Laycock and Tyson) showed that the growth regulant succinic acid 2,2-dimethyl hydrazide (also known as B995 and commercially available as Alar*) usefully modified the growth of vegetable crops. Two effects were considered worthy of further investigation, namely the reduction of apical dominance in Brussels sprouts and the modification of tuber size in potatoes, and a series of trials were undertaken in 1969 to examine these points.

MATERIALS AND METHODS

B995 was used as an 85% soluble powder. Trials were of randomised block design with fourfold replication; plot sizes were 18 ft x 7 ft for potatoes or 18 ft x 12 ft for Brussels sprouts. Application was through a precision plot sprayer using 50 gal water/ac. Potatoes were treated at tuberisation when effect on tuber size is at a maximum (Laycock). Sprouts were treated when the lower buttons were about ¼ in. diameter.

RESULTS AND DISCUSSION

Brussels sprouts

A comparison between treated, hand-stopped and untreated sprout yields at four harvest dates are given in Fig. 1. Both treatments similarly increased yield at the second and third harvests but only B995 increased yield at the first harvest. In the mild winter untreated plants continued to grow throughout and as a result gave the highest yield at final harvest date. Buttons from B995 treated plants were tighter and denser, but not larger, than those from the hand-stopped or untreated plants.

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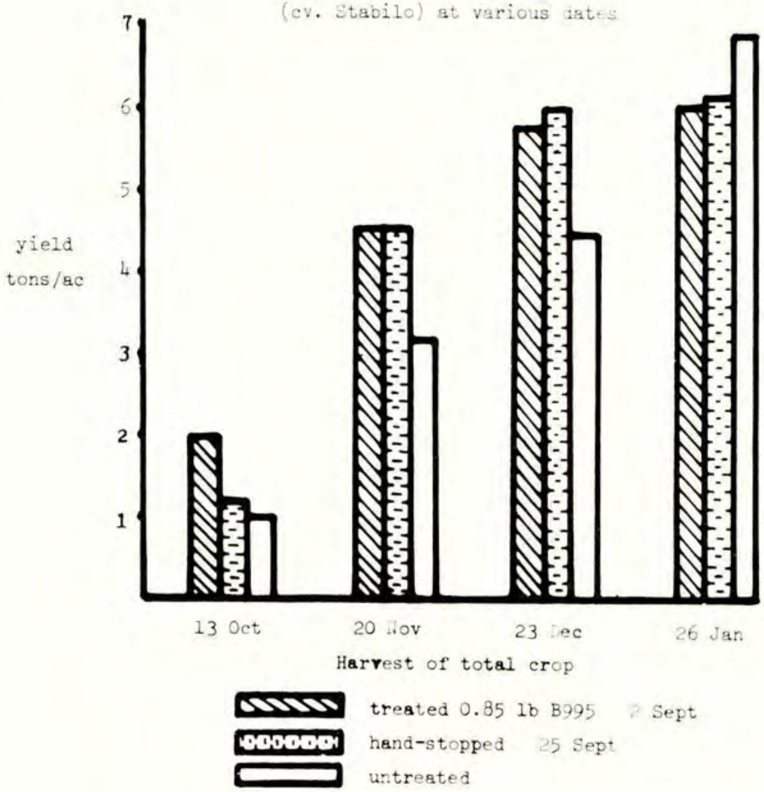
* Alar is a registered trademark of Uniroyal Inc.

Fig. 1

Yield of marketable sprouts
(cv. Stabilo) at various dates



Differences in response are demonstrated in Table 1 where those cultivars having a tall habit such as Stiekema responded more to B995 than did shorter ones such as Thor.

Table 1

Response of Brussels sprout cultivars to B995 treatment

Yields in tons/ac

Cultivars in order of height	Treatment in lb a.i./ac 0.425	0.85	1.70	3.40	Hand-stopped	Untreated
Thor	4.20	3.95	4.33	-	4.26	4.15
Indra	-	8.15	7.48	-	8.44	7.10
Bedfordshire-Milton Strain	2.04	2.11	1.68	1.73	1.75	1.95
Hybrid 30	2.69	3.13	3.04	3.13	3.47	2.58
Rollo	4.89	4.26	4.12	4.35	4.24	4.08
Stiekema	4.35*	4.60*	4.00	5.64*	4.94*	3.97
Stabilo	-	5.20*	5.29*	5.14*	5.54*	3.99

* indicates significant differences at $p = 0.05$

There were differences in results between 1968 and 1969 and these reflect the effect of season on plant growth and its interaction with B995. It is thought that beneficial effects from treatment with B995 are unlikely when there are environmental limits to growth. The current (1970) series of trials may supply further evidence on this point.

Potatoes

Yields of canning size tubers, total yields and tuber numbers are shown in Table 2. Varietal response is also demonstrated.

Table 2

Total yield, canning yield and tuber numbers after B995 treatment

Yields tons/ac

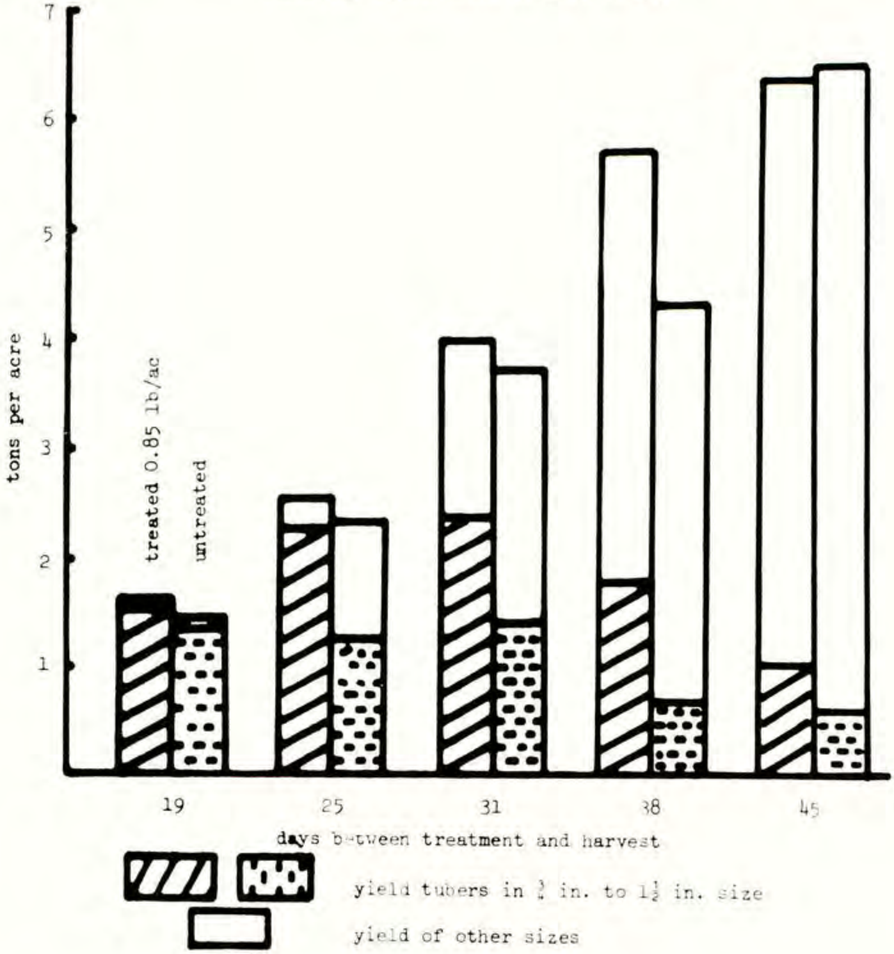
	Canning size tubers		Total		Tuber number 1000/ac	
	untreated	1.7 lb/ac	untreated	1.7 lb/ac	untreated	1.7 lb/ac
King Edward	2.21	2.50	6.18	5.35	124	173*
Arran Pilot	1.35	1.99	2.43	2.93	103	113
Royal Kidney	4.92	5.02	6.77	6.09	255	288
Duke of York	6.33	6.31	8.27	7.75	343	332
Maris Peer Site I	2.69	3.23*	4.20	4.46	148	153
Maris Peer II	2.56	3.94*	6.16	5.31	144	153
Maris Peer III	3.14	3.28	4.45	3.79	159	175

* indicates significant increase at $p = 0.05$

Maris Peer is the most responsive cultivar in our trials and this is demonstrated above. Timing of the harvest may prove to be critical in obtaining maximum cash return from the total crop and Fig. 2 illustrates the variations in amounts of canning sized tubers in the total yield and the differences therein over five different harvest dates. It will be seen that the maximum cash increment (assuming canning tubers fetch £50 and the remaining ware crop £16/ton) would come from the crop harvested at 25 to 31 days after treatment with 1.7 lb/ac B995.

Fig. 2

Yields of canning size and other tubers at various harvest dates following application of 0.85 lb B995



Treatment with B995 has not resulted in taint nor reduction in suitability for processing.

Maris Peer is also the only cultivar in Table 2 where haulm height and growth are markedly reduced after treatment with B995. Most cultivars have, in varying degree, horizontally orientated leaflets and flower abortion after treatment.

Reduction in tuber size as a result of B995 may also be of value in increasing yield of seed tubers. We have had 30 to 45% proportional increase by weight of 1 in. to 2 in. grade tubers in treated King Edward and intend to investigate this effect further. There have been conflicting reports on the performance of seed originating from B995 treated mother plants; we have found no carry-over effect in seed tubers of cvs. Royal Kidney, Maris Peer, King Edward or Record. In the other cultivar tested, Arran Pilot, chit size was reduced from 1.2 to 0.5 in., and emergence delayed from 7 to 10 days when compared to untreated seed. Bulking of tubers was also delayed.

Conclusion

As a result of the 1969 trials we are examining in 1970 the likely benefits resulting from the use of B995 in Brussels sprouts, where the taller varieties are picked once only, and in potato crops grown for production of canning sized tubers. Preliminary indications tend to substantiate this reported work and emphasise the differences in response of different cultivars to applications of B995.

We conclude that B995 is a potentially valuable but as yet imprecise tool for controlling growth in crops destined for processing and thereby increasing the yield and value of the crop.

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EFFECTS OF PLANT GROWTH REGULATORS ON HOST PLANT SELECTION BY APHIDS

B. D. Smith and E. A. Baker
University of Bristol, Long Ashton Research Station, Bristol, BS18 9AF

Summary The leaves of potato plants treated with gibberellic acid were lighter green than those of control plants, and dwarf beans treated with the growth retardants Succinic 2,2-dimethyl hydrazide or Chlormequat had darker green leaves than did control plants. When treated and control leaves were simultaneously exposed to swarms of flying *Aphis fabae* (Scop.) the aphids preferred to alight on the lighter green leaves. The growth retardants increased the plants' resistance to aphid attack; some implications of this for pest control are discussed.

INTRODUCTION

Some growth regulators are known to affect the development of pests and diseases on plants (Maxwell & Harwood, 1960; Sinha and Wood, 1964; van Emden, 1964), and plant growth retardants have been shown to affect the development of most of the pests and diseases attacking one host plant (Smith, 1969). It is also known that some regulators can change both the colour of leaves and the nature of their surface (Baker *et al*. 1968). Moore (1935) found that more aphids were attracted to potatoes sprayed with Bordeaux mixture than to unsprayed ones, and he concluded that this was because more intense light was reflected from the treated leaf surfaces. In a field experiment with 13 varieties and selections of peas, Cartier (1963) found that at an early seedling stage more aphids alighted and founded colonies on a variety with yellowish-green foliage, fewer settled on varieties with green foliage, and they were least abundant on a variety with deep green foliage. Cartier (loc. cit.), discussing the experiments of Robertson and Klostermeyer (1961), suggests that some difference in leaf colour was probably the reason why more *Myzus persicae* (Sulzer) visited one variety of field bean and transmitted virus to 95% of them, whereas fewer aphids visited another variety of which only 50% became infested with virus.

The results reported here are from preliminary studies to find whether the changes in appearance of plants treated with plant growth regulators affect the initial selection of plants by aphids.

MATERIALS AND METHODS

Winged *Aphis fabae* (Scop.) were produced by crowding the aphids on either dwarf bean (*Phaseolus vulgaris*) or broad bean (*Vicia faba*) plants. They were collected each morning and afternoon in glass jars from the tops of the culture cages. When it was possible to collect 50 - 100 aphids at one time in the jars, these were placed at the centre of the floor of a flight chamber. This chamber, designed by R. W. Gibson, was based on those used by Kennedy *et al*. (1961) and Kring (1966). It was circular, 1 m in diameter, painted white inside, and illuminated by a 150-watt bulb in the roof, separated from the chamber by nylon gauze. Aphids taking off from the tops of the jars flew towards the light but were prevented from reaching the gauze by the down-draught from a fan fixed above the light. By adjusting the fan speed it was possible to create a swarm of flying aphids, most of which remained in continuous flight for about an hour before settling on the 6 - 8 potted plants placed on the floor of the chamber. Small potato plants were used at first, but dwarf bean plants at the stage in which the first two leaves were ½ - ⅔ fully grown were found to be more suitable, because the aphids readily settled and reproduced on these leaves, and the flat horizontal surfaces could be easily measured and observed through small windows in the side of the chamber. The relevant leaves were equidistant from the light source because those projecting a few inches above others were preferentially selected; also it was found necessary to use leaves of similar size because aphids preferentially selected the largest. Plants were treated at varying times before being introduced into the chamber by dipping all foliage into either water + wetting agent (200 ppm. Manoxol O.T. 60), Succinic 2,2-dimethyl hydrazide (B-Nine or Alar), 2500 ppm. + wetting agent, Chlormequat (Cycocel or CCC), 2500 ppm. + wetting agent, or gibberellic acid (GA) 50 ppm. Those plants and leaves treated with water + wetting agent only are referred to as controls.

Some aphids alighted on plants after flying for only a few minutes, but most flew for ½ - 1 hour. Within minutes of landing on the upper surfaces they moved to the undersides of the leaves where they subsequently reproduced. Very few aphids alighted on parts of the chamber. When all aphids had ceased to fly the plants were removed and the aphids counted.

Wax determinations were made by the method described by Baker et al. (1968). Variations in leaf colour following the various treatments were assessed from diffuse reflection measurements (from 360 mμ to 680 mμ) obtained using the Unicam SP.735 Diffuse Reflectance attachment to a Unicam SP.700 Spectrophotometer.

EXPERIMENTS AND RESULTS

1. The leaves of young potted potato plants treated with gibberellic acid were lighter green than those on the controls and some of each were introduced into the flight chamber. It was found that 76% of the aphids alighted on the treated leaves and 28% on the darker green controls.

2. A batch of dwarf bean plants was treated with the growth retardant Succinic 2,2-dimethyl hydrazide. At 1, 2, 4 and 6 days after treatment some of these were exposed in the flight chamber with equal numbers of controls.

Table 1

<u>% total aphids alighting on plants</u>

Days after treatment	With Succinic 2,2-dimethyl hydrazide	Controls
1	57	42
2	40	60
4	19	81
6	10	90

The results (Table 1) show that by the fourth day aphids clearly alighted preferentially on the control leaves, which, whilst being of similar size to the treated leaves, were of a lighter green colour. By the sixth day this colour difference and aphid preference were more pronounced, but the experiment was terminated after this because the treated leaves were smaller than the controls; also secondary leaves were developing at a greater rate on the controls.

3. Some dwarf bean plants were treated with the growth retardant Chlormequat, and these were used firstly to provide an alternative to Succinic 2,2-dimethyl hydrazide, and then in a combined experiment with controls and plants treated with Succinic 2,2-dimethyl hydrazide. When plants treated 4 days earlier were used, aphids alighted preferentially on those treated with Chlormequat when the only alternative was those treated with Succinic 2,2-dimethyl hydrazide; when untreated plants were added, the proportion of the total alighting on the Succinic 2,2-dimethyl hydrazide group was similar, but most aphids preferred the controls (Table 2). To the human eye, the leaves treated with Succinic 2,2-dimethyl hydrazide were darkest green, the controls lightest green, and the Chlormequat-treated intermediate in colour.

Table 2

% total aphids alighting on plants

Succinic 2,2-dimethyl hydrazide	Chlormequat	Controls
15	85	-
11	20	68

When the plants were removed from the chamber the colour of the leaves was measured. The leaves of all treatments had diffuse reflectance maxima at 552 mμ. Comparisons between leaves of varying colours showed that reflectance measurements at this wavelength give a direct assessment of the intensity of the green component of the leaf colour. The diffuse reflections expressed as a percentage of that from a white standard surface of magnesium oxide at 552 mμ were Control, 9.5%; Chlormequat-treated, 5.5%; Succinic 2,2-dimethyl hydrazide-treated, 3.4%. These figures support our visual assessment of the small differences in colour intensity between the treatments. The absence of a complex wax structure or other surface features such as trichomes and papillae on the upper surface of dwarf bean leaves, as revealed by the Scanning Electron Microscope, confirmed our findings that the direct superficial reflections are at a minimum for this surface. Since it is known that some growth retardants may cause changes in the composition of the leaf cuticle (Baker et al. 1968) the amount of surface wax was determined. It was found that the amount of surface wax on the primary leaves of the control plants and on those of plants treated with Succinic 2,2-dimethyl hydrazide and Chlormequat was similar, 0.01 mg/cm^2.

DISCUSSION

Many aphid species are attracted to green and particularly to yellow surfaces. Kennedy and Stroyan (1959) suggest that since young and senescing leaves are yellower than mature ones the special effectiveness of yellows in causing alighting and probing may have more to do with the nutritional and physiological status of the hosts than with their taxonomic status. Kennedy et al. (1961) found that alightments by Brevicoryne brassicae and Myzus persicae in the field occurred preferentially on leaves reflecting a greater proportion of long wave energy, with little or no regard for the 'botanical' (plant taxonomic) host status of the plants for each aphid.

The main difference between leaves of treated plants and controls in these experiments appeared to be in colour intensity; it is suggested that this is why the plants treated with gibberellic acid were more susceptible to attack than the controls, and why those treated with the growth retardants were more resistant to attack. Aphis fabae can evidently distinguish between leaves which differ only slightly in colour; the extent of this discrimination is being investigated further.

Increased resistance in plants to aphids is especially important where aphids transmit virus diseases to crop plants which are their normal hosts. However, many aphids flying over crops may be potential virus vectors and may transmit non-persistent viruses in a few seconds if they land and probe on plants they cannot colonize (Heathcote et al. 1969). Any method by which the attractiveness of crops to aphids can be reduced is potentially valuable since it may lead to a reduction in the use of insecticides and assist the development of an integrated control system.

The plant growth regulators used in these experiments are in use commercially or experimentally at similar concentrations on a variety of crops, and investigations are in progress to find whether the effects reported here are significant in the field.

Acknowledgments

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THE EFFECTS OF 2-CHLOROETHYLPHOSPHONIC ACID AND CHLORFLURECOL-METHYL UPON THE SPROUTING OF AGROPYRON REPENS (L.) BEAUV. RHIZOMES

R.J. Chancellor
ARC Weed Research Organization, Begbroke Hill, Sandy Lane, Yarnton, Oxford

Summary Decapitated seven-node fragments of Agropyron repens rhizomes were incubated on paper moistened with water, 2-chloroethylphosphonic acid ('Ethrel', G 996, CEPA) or methyl-2-chloro-9-hydroxyfluorene-9-carboxylate (chlorflurecol-methyl). Both chemicals delayed the onset of dominance amongst shoots and allowed them to continue growing longer than in controls; but CEPA only delayed dominance if the rhizome fragments had leafy shoots already attached to them, as otherwise dominance was enhanced. Buds from rhizomes treated with CEPA grew into new rhizomes and not leafy shoots. The number of roots was increased, but they were shorter than controls. Shoots from rhizomes treated with chlorflurecol were frequently deformed and grew in circles or spirals. Occasionally secondary lateral shoots grew out from them. Root production was virtually inhibited by chlorflurecol at 20 ppm.

INTRODUCTION

Dormancy is an important feature of weeds for without it they would be far more vulnerable to control measures. This is equally true of the seeds of annuals as of the vegetative buds of perennials. Therefore the ability to break or prevent dormancy in either could be of considerable importance.

Agropyron repens, one of the worst perennial weeds in British agriculture, has an effective system of regeneration from rhizome fragments, which is based largely upon a system of lateral bud dormancy. At the Weed Research Organization rhizome fragments have been grown in growth chambers (Chancellor, 1968) to investigate the growth patterns of their lateral buds. The results indicate that in this country dormancy of the buds is due solely to apical dominance (correlative inhibition) and not additionally to some other form of dormancy such as has been found in N. America (Johnson & Buchholtz, 1962).

It has been suggested that seed dormancy might in many instances be broken chemically (Harper, 1957) and there is no reason why this should not be equally possible for perennating buds. Indeed tests for this purpose have already been carried out (Meyer & Buchholtz, 1963; Hull, 1970 etc.). At the Weed Research Organization a technique (Blair et al, 1970) has been devised for the routine testing of chemicals on bud dormancy and subsequent shoot growth of A. repens rhizomes. This paper gives detailed results obtained by this method with two growth-regulating chemicals

METHOD AND MATERIALS

In all these experiments Agropyron repens clone No. 31 (Headington clone) of the Weed Research Organization couch-grass collection was used, although in one experiment, 3 other clones were also tested. Rhizomes were freshly dug up in the field for each experiment and were never more than one year old. The fragments were 7-node pieces and cut from the middle of long rhizomes unless they had leafy aerial shoots attached. Before use they were washed and stripped of roots and scale leaves.

After preparation the fragments were attached to strips of Whatman's 3MM chromatographic paper moistened with test solutions and incubated at 24°C in glass jars as described elsewhere (Blair et al, 1970). The jars were kept in the dark and assessed in the light unless leafy shoots were attached when they were kept throughout in daylight.

The chemicals tested were 2-chloroethylphosphonic acid ('Ethrel', G 996, CEPA) at 50 ppm and methyl-2-chloro-9-hydroxyfluorene-9-carboxylate (chlorflurecol-methyl) at 20 ppm. In all instances 200 ml of chemical, water or Hoagland's nutritive solution (full strength) were added to each jar.

Assessments were made every 2-3 days by measuring shoot lengths and in some experiments root lengths to the nearest mm.

RESULTS

(a) Chlorflurecol-methyl

Under the conditions of testing a majority of the hitherto dormant buds on untreated 7-node fragments start into growth after the rhizome apex is removed: but many stop again later and after 10-20 days usually only one shoot remains growing. This one persists as the new dominant shoot replacing the original rhizome apex.

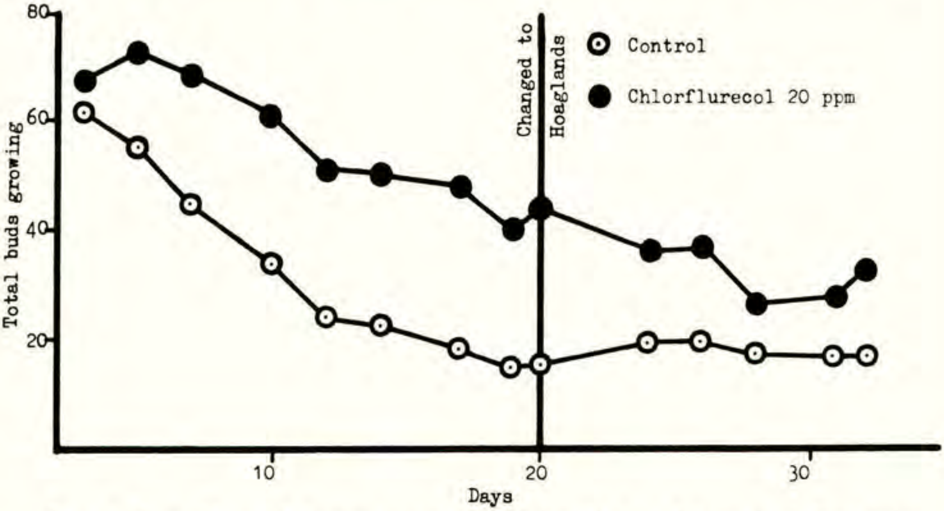

Fig. 1 The effect of 20 ppm chlorflurecol for 20 days followed by Hoaglands nutritive solution no. 1 on the number of buds growing on twelve 7-node rhizome fragments

Preliminary tests showed that chlorflurecol interferes with this reassertion of dominance so a further experiment was set up with treatments of distilled water and chlorflurecol at 20 ppm. The effect on the onset of dominance among shoots was assessed by counting the number of shoots actually growing at each assessment. The results are given in Fig. 1.

On the 12 rhizomes treated with water 82% of the buds had ceased growth by 20 days, but the corresponding proportion with chlorflurecol was only 55%. This is a promising result which indicates the ability of this chemical to delay the reimposition of dormancy by a dominant shoot. On the twentieth day, the shoots and rhizomes of a further 24 fragments were oven dried and weighed separately to find what proportion of the total weight was located in the new shoot and root growth and whether chlorflurecol affected nutrient transport or availability. However, there was little difference between treatments, 13.2% of the total weight being found in new shoots on chlorflurecol-treated rhizomes and 11.6% on control rhizomes.

To test if nutrient depletion accounted for any of the shoots ceasing growth on the original 24 rhizomes, the water and chemical solutions were replaced on the twentieth day with Hoagland's nutritive solution No. 1 (full strength). This resulted (Fig.1) after 6 days in an increase of 6% in the number of shoots growing in the controls. No such increase occurred with chlorflurecol-treated rhizomes, at least until 8 days after the nutrients were added, when 6 further shoots - mainly secondary laterals - made growth.

Besides affecting the growth patterns of the shoots, chlorflurecol also affected the shoot morphology. The leaves were narrow and many of the shoots grew out in wide spirals or in circles, while others were perfectly straight. A further effect upon the shoots was that dormant buds at the base of the new lateral shoots occasionally grew out to form secondary lateral shoots, a feature never before observed at this stage of growth. This was all the more remarkable in that it frequently occurred when the primary laterals themselves were growing rapidly. The rates of growth of primary laterals ranged from 0-22 mm/day at the time of appearance of the secondary laterals (32 mm/day is the fastest rate of growth of a primary lateral so far recorded in this work). Although there were three times more shoots growing on the chlorflurecol-treated rhizomes than on the control ones at the twentieth day, the mean shoot length was only 12.5% longer and the mean increment/growing shoot/day showed no clear pattern of behaviour for either treatment (Fig. 2) relative to the number of shoots growing (Fig. 1).

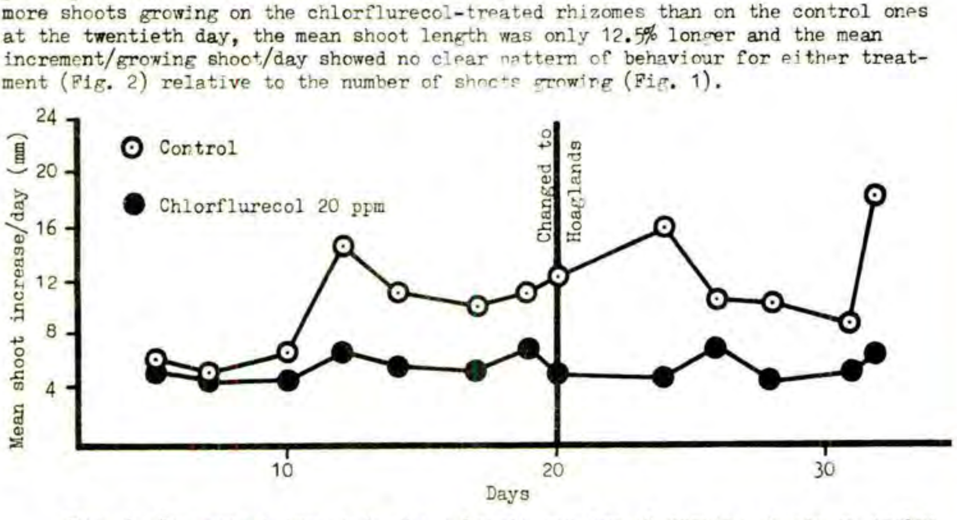

Fig. 2 The mean increase in shoot length per day of growing shoots on twelve 7-node rhizome fragments treated with water and 20 ppm chlorflurecol

Chlorflurecol also affects root production (Krelle, 1968). Root measurements were made on eight 7-node rhizome fragments treated with either distilled water or chlorflurecol at 20 ppm. After 20 days the untreated rhizomes averaged 17 roots per fragment with a total length per fragment of 646 mm, while those treated with chlorflurecol developed no roots at all. When this experiment was repeated similar results were obtained, although 3 roots with a total length of 10 mm were produced on the four fragments treated with chlorflurecol.

(b) 2-Chloroethylphosphonic acid (CEPA)

Preliminary tests with CEPA at 50 ppm on rhizome fragments were disappointing, for shoots were on average 51% shorter than on control rhizomes and absolute dominance was asserted 3 days earlier, although this chemical is known to relax apical dominance (Caseley, 1970). To find the cause of this discrepancy rhizomes were tested with their apices attached, then grown in light or in darkness and then different clones of A. repens were employed; but always with the same result. Finally tests were made on rhizome fragments that had a single leafy shoot already attached to them. This proved successful for a considerable number of laterals grew, and after 20 days 58% of them were still growing as compared with only 21% on the controls (Fig. 3).

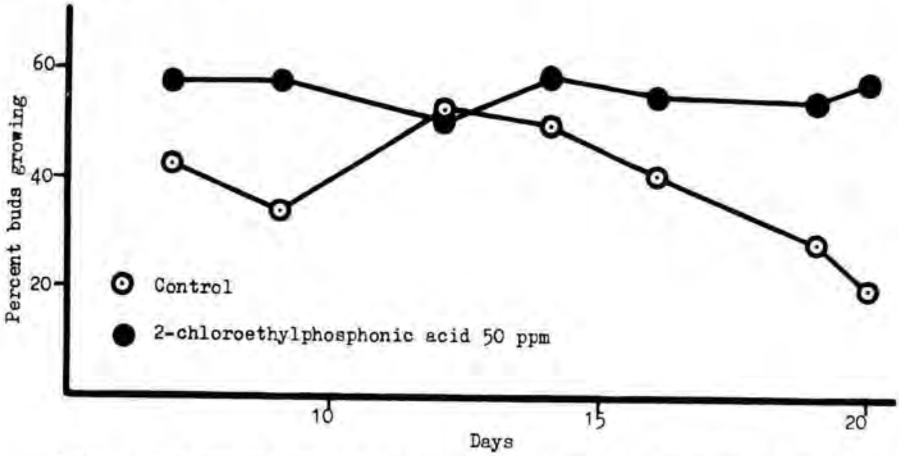

Fig. 3 The effect of 50 ppm 2-chloroethylphosphonic acid on the percentage of buds growing on rhizomes with leafy shoots attached

In contrast to chlorflurecol, CEPA actually causes a greater number of roots to be formed. This may be due in part to the greater number of available root sites, for the new shoots grow out as rhizomes and produce roots at the basal side of each node. Although more roots are produced they are in fact shorter on average than on untreated rhizomes so that the total root lengths are similar. On four untreated 7-node rhizomes after 20 days there were 57 roots with a total length of 293 cm while on four CEPA-treated rhizomes there were 141 roots with a total length of 290 cm. The mean increment in shoot length per day of growing shoots (Fig. 4) gradually increased with time on the controls and this could be associated with the declining number of shoots growing. However, the daily increment was more or less constant on ones treated with CEPA, also possibly due to the relatively constant number of shoots growing (Fig. 3). This definite pattern of behaviour contrasts with that of rhizomes without leaves attached (Fig. 2).

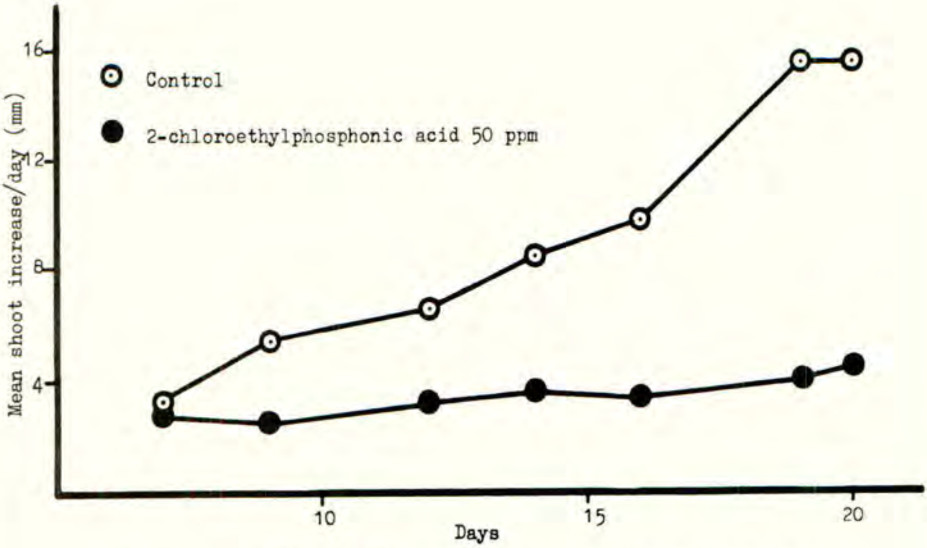

Fig. 4 The effect of 50 ppm CEPA on the mean increase in shoot length per day of growing shoots on rhizome fragments each attached to a single leafy parent shoot.

DISCUSSION

In pea seedlings it has been shown (Tognoni, 1968) that chlorflurecol inhibits the transport of auxin. From the behaviour of shoots on rhizome fragments the prevention or diminution of movement of auxin could be an explanation of the results presented in this paper. The growth of secondary laterals from primary laterals, often at a time when the primary laterals themselves are growing stongly, supports this. The fact that ~~6%~~ more shoots started growing on the controls after adding nutrients suggests that food availability as well as the dominance system influence the number of shoots growing. However, the chlorflurecol-treated rhizomes were apparently unaffected initially by the addition of nutrients and showed a continued decline in the number of shoots growing. Later several secondary laterals started growing, which reversed the process. The lack of any appreciable difference in the amount of dry matter located in the new shoots suggests that chlorflurecol does not affect nutrient availability.

It appears then that chlorflurecol, probably by reducing auxin movement, reduces to some degree the onset of dominance amongst primary lateral shoots and under certain circumstances, not yet fully understood, allows secondary buds at the base of the primary laterals to grow out. CEPA, in contrast, although apparently also delaying or preventing dominance among primary laterals, never breaks the dormancy of secondary laterals; hence the encouragement of growth of primary laterals, which are morphologically rhizomes, in fact increases the number of dormant rhizome buds present on the new plant.

The lack of root formation with chlorflurecol could of itself constitute a serious handicap for the plant and reduce rhizome survival. Conversely rhizomes treated with CEPA produce more roots than the controls, although they are shorter. Whether these changes affect function or not is unknown.

CEPA produces ethylene (Warner & Leopold, 1969) and ethylene has been shown to inhibit auxin transport in cotton stem sections (Beyer & Morgan, 1969) so its mode of action may be similar to that of chlorflurecol, although other symptoms are different. CEPA only prevents dominance when leafy shoots are attached to the rhizomes, a feature also recorded for Sorghum halepense (Beasley, 1969) and this suggests that some photosynthetic product is an essential intermediary in its action. Without leaves dominance is enhanced, which could limit the use of this chemical for encouraging the growth of dormant buds.

These results are of interest for they throw some light on the mechanism of dominance in this plant and may yield a new method of controlling rhizomatous weeds. If all dormant buds could be persuaded to grow, even if only temporarily, then not only would this contribute to a more rapid depletion of food reserves in the rhizomes, but the partly-grown shoots would also be more susceptible to other more conventional methods of control.

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Proc. 10th Br. Weed Control Conf. 1970

EFFECTS OF 2-CHLOROETHYLPHOSPHONIC ACID (ETHREL*) ON TUBER SIZE AND NUMBER IN POTATOES

I. J. Dixon and Susan P. Sharp
A.H. Marks and Company Limited, Wyke, Bradford

Summary Potatoes of the varieties Pentland Crown and Majestic were treated with 2-chloroethylphosphonic acid (CEPA) as a foliar spray at 4 rates at 4 different stages of growth covering the period of tuber initiation. A decrease in the mean tuber size was observed, a larger number of tubers falling into the small size grade ($<1\frac{1}{2}$ in.). The total number of tubers formed was not significantly increased, but the overall yield was significantly reduced, the reduction being greater at the higher application rates and at the later dates of application. The application of these results to 'seed' tuber and canning potato production is discussed.

INTRODUCTION

The buds forming the 'eyes' of the potato tuber are initially dormant and remain in this condition for a varying period of time, depending on the variety and conditions of storage. When dormancy is broken, growth is greater in the case of buds near to the 'rose' end; the buds near the apex of the stem inhibiting the growth of buds further away.

New tubers are produced from stems arising at the underground nodes and, other things being equal, an increase in the number of nodes, by increasing the number of stems produced or by shortening the internode length, will tend to give an increase in the number of tubers produced.

With the growing demand for small tubers for canning and 'seed', an increase in the number of tubers produced with a greater percentage in the small size ranges, would be an advantage.

Preliminary work with 2-chloroethylphosphonic acid (CEPA) (Amchem, 1969) on potatoes, as a foliar spray, has shown a tendency to break the dormancy of the eyes and to initiate tuber formation (Catchpole and Hillman, 1969). This should increase the number of tubers formed and, to investigate this effect, two trials were laid down using two cultivars of potato with application of four rates of CEPA at four dates during the growing season.

METHOD AND MATERIALS

Site 1:	Burnholme East, Wyke, Bradford
Soil type:	Clay loam
Cultivar:	Pentland Crown

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* Trade Mark of Amchem Products Inc.

Date of Planting: 5th June 1969 - Late planting due to wet soil early in spring.

Pre-Emergence Herbicide: 17th June - Linuron. 1 lb a.i./ac.

Site 2: Blyth, Nottinghamshire

Soil type: Light, sandy loam

Cultivar: Majestic

Date of Planting: 1st May 1969

Each site was laid out and treated in an identical manner.

Layout: Fully randomised block - 6 replicates

Plot size: 2 yards x 6 yards, covering 2 whole rows with a half row on each side acting as a guard row between plots.

Treatment:
.125 lb a.i. CEPA/acre + wetter *) Repeated at
.250 lb a.i. CEPA/acre + wetter) 4 different
.500 lb a.i. CEPA/acre + wetter) stages of
.750 lb a.i. CEPA/acre + wetter) growth
Untreated control.

*The wetter used was an Alkyl aryl polyglycol ether.

Dates of treatment:		1) Wyke	2) Blyth
95% emergence + 1 week	T1	14th July 1969	13th June 1969
	T2	25th July 1969	27th June 1969
	T3	4th August 1969	11th July 1969
	T4	18th August 1969	25th July 1969
Haulm killer applied (Dinoseb in Oil 1.8 lb a.i./ac.)		7th October 1969	12th October 1969

On both sites an Oxford Precision Sprayer was used with 'O' jets at 26 p.s.i. giving 30 gallons per acre at 2 m.p.h.

Conditions were good at spraying in all cases, a little wind and warm conditions. Plants were dry at all times of application. Herbicides and haulm killer were applied with a tractor-mounted sprayer.

Harvesting was started 14 days after application of the haulm killer at Wyke, and 20 days after at Blyth. Lifting was done with a tractor-mounted spinner which gave little or no displacement of the tubers in the row. The grading and weighing were carried out approximately 14 days after lifting.

Tubers were graded by hand into 3 sizes; less than 1½" diameter, 1½" - 2½" diameter and over 2½" diameter, corresponding to canning, seed and large ware sizes. The number and weight of the tubers from each grade were recorded for each plot, and the mean % of the total weight and number for each grade (from 6 replicates) are shown in the table of results.

A statistical analysis of the results was carried out. Because of the experimental design, which was affected by limitations of space, there is only one control plot per replicate and the experiment is not a full 5 x 4 factorial design. A separate analysis has been carried out to determine the main effects of CEPA and time of application, and to determine if there is any interaction of the two.

RESULTS

The foliage showed very little effect at the two lower rates of CEPA, but at the higher rates leaf rolling and dwarfing were apparent. No measurements of these effects were made.

The total yields are low due to a combination of late planting and dry summer conditions, being of the order of 9 tons per acre at Wyke and 3 tons per acre at Blyth. These results may not,therefore, be truly representative of a normal year.

Table 1 - Total crop weight (lb per plot)

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	31.5	28.3	25.4	29.3	13.0	11.4	10.1	10.8
0.25	29.1	31.9	24.5	24.5	11.3	12.7	9.8	9.8
0.50	24.3	29.6	25.0	23.0	9.0	10.3	9.0	8.8
0.75	24.1	23.3	20.5	21.8	8.3	10.7	8.0	9.8
Control	32.9	S.E. ±	3.28		Control	11.8	S.E. ±	1.54

At both sites there was a significant reduction in the total yield. 0.75 lb a.i. CEPA/ac gave the greatest reduction at Wyke, but on the lighter soil at Blyth the difference between 0.5 and 0.75 lb a.i./ac was not significant. Time of application is important, the later applications generally giving greater reductions (Table 1).

Table 2 - % by weight less than $1\frac{1}{2}$"

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	9.4	11.4	11.4	12.7	35.8	28.9	52.8	42.6
0.25	9.9	10.3	14.1	16.5	30.1	40.0	48.7	38.0
0.50	14.2	10.9	13.7	23.3	44.0	47.2	57.3	48.9
0.75	13.6	14.6	15.3	24.9	41.0	42.5	61.5	58.0
Control	8.3	S.E. ±	0.44		Control	37.4	S.E. ±	1.02

The percentage of tubers less than $1\frac{1}{2}$ in., by weight, was significantly increased by treatment with CEPA (P = 0.001), the latest date of treatment being particularly effective, along with the highest rate of CEPA (Table 2).

Table 3 - % by weight $1\frac{1}{2}$ - $2\frac{1}{2}$ in.

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	64.0	56.8	76.1	75.2	63.52	71.10	47.20	57.40
0.25	69.2	62.3	70.3	70.8	69.90	58.28	51.30	62.00
0.50	72.4	64.9	73.0	69.8	55.18	52.80	42.70	51.10
0.75	72.9	71.4	77.8	63.2	59.00	57.50	38.50	42.00
Control	65.6	S.E. ±	0.76		Control	61.13	S.E. ±	1.16

At Wyke, the difference in weight in the $1\frac{1}{2}$ - $2\frac{1}{2}$ in. size range was not significantly different for the 4 rates of CEPA (Table 3), but time of application gave different yields (P. = 0.001). At Blyth, both time and rate of application of treatment gave significantly different results (P = 0.001).

Table 4 - Total number of tubers per plot

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	159.3	155.2	159.7	192.2	120.3	105.7	124.8	126.2
0.25	163.3	172.5	162.0	184.5	102.0	147.2	124.0	111.5
0.50	166.0	163.7	170.3	221.2	103.0	113.5	130.5	122.7
0.75	157.5	159.3	159.2	202.7	88.2	122.8	128.7	144.7
Control	166.7	S.E. ±	21.28		Control	118.7	S.E. ±	15.33

The total number of tubers was increased by treatment with 0.5 lb a.i. CEPA/ac on the latest treatment date at Wyke. At Blyth, the total number of tubers was unaffected by the treatments, but averaging all treated plots at each time shows a significant reduction (P = 0.01) at the first time of application (Table 4).

Table 5 - % by number less than $1\frac{1}{2}$ in.

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	34.9	38.5	37.1	40.5	61.6	56.0	75.7	69.2
0.25	35.2	36.7	43.2	47.4	54.8	70.5	74.7	65.8
0.50	43.0	39.9	43.1	60.1	69.6	69.3	80.6	74.5
0.75	41.9	44.9	45.9	61.5	65.8	70.8	83.8	80.7
Control	32.7	S.E. ±	0.79		Control	64.1	S.E. ±	0.81

The percentage of number of tubers under 1½ in. diameter has been increased by treatment with CEPA (P = 0.001) at both sites, the latest date of treatment being particularly effective, along with the highest dosage of CEPA (Table 5).

Table 6 - % by number 1½ to 2½ in.

	Wyke				Blyth			
CEPA lb/ac	T1	T2	T3	T4	T1	T2	T3	T4
0.125	55.4	53.8	58.9	55.9	38.15	44.00	24.30	30.80
0.25	58.0	54.2	51.7	49.2	45.20	29.08	25.30	34.20
0.50	53.5	51.7	52.6	38.3	30.23	30.70	19.40	25.50
0.75	54.3	51.2	52.0	35.9	34.20	29.20	16.20	19.30
Control	58.2	S.E. ± 0.58			Control	35.5	S.E. ± 0.84	

A significant reduction (P = 0.001) in the number of tubers in the 1½ - 2½ in. size range was observed at both sites (Table 6). Corresponding reductions were noted also in the size range above 2½ in. diameter.

DISCUSSION

The applications of CEPA extended over a range of concentrations and timings which, as far as possible, covered the period of tuber initiation in the hope that at this stage an increase in tuber numbers could be obtained to counteract the possible decrease in yield due to reduced tuber size. However, it appears that later applications of CEPA have an enhanced effect both in increasing the percentage of small tubers and in reducing yield. Early applications, although producing a larger number of small tubers, also reduce the total yields considerably.

With regard to the canning size tubers (½ - 1½ in. diameter) there is a 7-15% increase in proportional weight, corresponding to a 30-150% increase in actual weight. This could well be of importance, particularly if it could be combined with present methods of high density cropping for small tuber production, to obtain 80% or over of canning size tubers.

Assuming that the results here are typical, it appears that the most effective rate of use would be 0.125 - 0.50 lb/ac applied 4 - 6 weeks after emergence, when the potatoes have about 15 leaves per shoot.

Further experiments are in progress to determine if dipping seed pieces in a combination of CEPA with gibberellic acid will give the required increase in shoots per unit area; this would be followed by foliar sprays of CEPA at approximately the times used here to provide a stimulus for tuber initiation.

References

AMCHEM PRODUCTS INC. Technical Service Data Sheet E-172 'Ethrel' April 1969, Ambler, Pa., U.S.A.

CATCHPOLE A.H. & HILLMAN J. (1969) Effect of ethylene on tuber initiation in *Solanum tuberosum* L. Nature 223 No. 5213, 1387.

EFFECTS OF 2-CHLOROETHYLPHOSPHONIC ACID (ETHREL*) ON FACTORS AFFECTING YIELD IN SPRING BARLEY

R. Murray
Department of Biology, University of Strathclyde, Glasgow
I. J. Dixon
A.H. Marks and Company Limited, Wyke, Bradford

Summary Field and glasshouse experiments with 2-chloroethylphosphonic acid (CEPA) indicate that stem length in barley cvs. Proctor, Julia and Sultan can be reduced to counteract the tendency to lodge at high nitrogen fertilizer levels. Associated detrimental effects include reductions in ear density and weight of grain per ear. It is postulated that these effects may be due to the anti-auxin activity of CEPA. A reduction in area of the flag leaf and its associated photosynthetic organs and interference with cell expansion in the ear primordium are suggested explanations for the decreased yield.

INTRODUCTION

One of the major factors determining present maximum yields of spring barley is the tendency of the crop to lodge with high application rates of nitrogenous fertilizers. In wheat, Caldicott (1966) has shown a yield increase following application of chlormequat to reduce early lodging. The decreased lodging has been shown to be due partly to an improved root system and partly to thickening of the stem. Humphries and Bond (1969) give details of the effect of chlormequat on several wheat cultivars and of its effect on the various components which make up the total yield.

2-chloroethylphosphonic acid (CEPA) releases ethylene by a base catalysed elimination reaction (Cooke and Randall, 1967). Ethylene is a well known growth regulator: among its activities are the breaking of dominance and the inhibition of growth by cell extension (Osborne, 1968; Pratt and Goeschl, 1969). CEPA, applied to cereal crops at a variety of rates and times, gave useful results in wheat, rye and barley at rates from $\frac{1}{2}$ - 2 kg. a.i./ha when applied at about the stage of elongation of the main stems.

As a result of these preliminary findings a programme of field and glasshouse trials was started to determine in more detail the effect of CEPA on the yield components, and also the effect of increasing nitrogen fertilisation in barley, a crop which at present cannot be successfully and economically treated with chlormequat.

METHOD AND MATERIALS

1. Field Trials For the field experiments spring barley was sown at 1 - $1\frac{1}{4}$ cwt ac in 7 in. rows after a seed bed application of 4 cwt/ac of a 15:15:15 compound fertiliser. Soil pH was 5.8 at site 1 and 6.4 at site 2.

*Trade Mark of Amchem Products Inc.

An investigation of the effect of additional nitrogen was carried out on one cultivar at each site, 30 units/ac of a 38% N material were applied as a top-dressing at the time of spraying. CEPA was applied as a 50% solution in propylene glycol diluted and applied in 30 gal/ac of water with an Oxford Precision Sprayer. The rates used were 0, 0.25, 0.5, 0.75 and 1.0 lb a.i./ac. A spray supplement of either a herbicide containing Ioxynil, 2,4-DP and MCPA at 4 pints/ac or a wetting agent at 0.01% was used, giving a final total of 16 treatments arranged as a 4 x 2 x 2 factorial design, with a randomised block layout with 4 replicates.

Samples of 5 mature plants were collected at random along the diagonals of each plot, giving a total of 10 plants per plot. Measurements were made of tiller number, number of tillers heading, length of mature tillers with ears, grains per ear and 1,000 grain weight. An analysis of variance was performed on these results and the standard error values are included in the tabulated results.

2. Glasshouse Trials Barley seeds were planted at intervals in John Innes No. 2 compost in 3 in. polystyrene pots and grown in a glasshouse under optimum light and watering conditions. Using a chromatography sprayer, application of CEPA was carried out at the appropriate growth stages on 9th July 1969. The experimental layout was as follows:-

Cultivars:	3	(Sultan, Proctor, Julia)
Stages:	4	(D/E, F/G, H/I, I/J)
Concentrations:	5	(0, $\frac{1}{4}$, $\frac{1}{2}$, 1 & 2 lb/a.i. ac)
Formulations:	2	('Ethrel' technical grade and Amchem Formulation 68-250)
Replicates:	3	
Total	360 plants	

D/E - one shoot - start of tillering.

F/G - tillers formed - lengthening of leaf sheaths.

H/I - leaf sheaths erected - first node visible.

I/J - first node visible - second node visible.

Harvesting was carried out in September 1969, records being taken of the number of tillers per plant, plant weight, number of heads per plant, straw length and 1,000 grain weight. Analysis of variance was carried out on the results.

RESULTS

Site 1: Wyke, Bradford, Yorkshire

CEPA gave significant decreases both in length of straw and grains per ear at its higher application rates, 1,000 grain weight also decreased, this decrease occurring at a lower level of CEPA when more nitrogen was applied (Table 1).

In spite of a significant increase in the number of tillers produced, the percentage of these reaching maturity is greatly reduced, resulting in similar or only slightly higher ear population in treated plots compared with those not treated with CEPA. The net product of these results would indicate a very great reduction in yield at the 1 lb/ac rate of CEPA not compensated for by increasing nitrogen fertilisation.

Table 1

Site 1: Wyke, Bradford, Yorkshire

Cultivar	Julia
Stage of growth at spraying	- I -
Date of spraying	24th June 1969
Date of assessment	11th August 1969
Grain samples taken	7th September 1969

16 treatment combinations of CEPA (4), Nitrogen (2), Wetter (2)

CEPA lb/a.i./ac		Nitrogen units/ac		Wetter (Cit) or herbicide (Cert)	Mean length of tillers cm.	Number of tillers per 10 plants	% Tillers Heading	Mean grains per ear	1,000 grain weight
0	+	60	+	Cit	39.85	90.0	61.78	21.1	40.86
0	+	60	+	Cert	47.50	102.0	71.42	21.0	43.00
0.5	+	60	+	Cit	45.70	136.0	69.78	20.8	40.83
0.5	+	60	+	Cert	39.80	142.0	59.82	20.1	40.04
0.75	+	60	+	Cit	39.30	140.0	58.48	20.4	40.65
0.75	+	60	+	Cert	44.00	125.0	68.88	20.7	41.36
1.0	+	60	+	Cit	35.90	148.0	44.51	20.1	34.88
1.0	+	60	+	Cert	39.50	137.0	45.74	22.2	38.73
0	+	90	+	Cit	44.90	116.5	68.93	22.6	44.10
0	+	90	+	Cert	45.40	138.0	54.30	22.7	41.34
0.5	+	90	+	Cit	41.70	126.0	54.90	19.6	40.03
0.5	+	90	+	Cert	41.70	136.0	58.65	20.6	42.00
0.75	+	90	+	Cit	38.87	125.0	65.27	20.1	39.82
0.75	+	90	+	Cert	41.00	150.0	54.54	20.1	39.41
1.0	+	90	+	Cit	37.45	148.0	46.09	20.3	39.89
1.0	+	90	+	Cert	39.90	146.0	55.46	20.4	40.69
				S.E.	± 3.09	± 21.0	± 5.2	± 0.82	± 2.09

Site 2: Thirsk, Yorkshire

In this experiment, the results are essentially similar to those already described. There was a tendency towards a shorter straw in those plots treated with herbicide, although this was not significant. The net result of the treatment was to reduce the yield considerably as a result of decreases in ear density, grains per ear and 1,000 grain weight. The application of extra nitrogen did improve the yield, but did not compensate entirely for the CEPA treatment (Table 2).

Glasshouse

Tillering (Table 3) Analysis of variance revealed significant differences in response to CEPA according to cultivar ($P = 0.001$) and stage of growth at the time of treatment ($P = 0.001$). Evidently a complex inter-relationship exists between cultivar/stage of growth/concentration ($P = 0.05$) in which the degree of tillering of Sultan and Julia is particularly stimulated at 0.25 and 0.5 lb/ac doses applied at the older growth stages.

Weight of plant (Table 4) The effect of CEPA treatment varied significantly according to cultivar ($P = 0.001$) and the stage of growth at the time of application ($P = 0.001$). Greatest reductions in weight were recorded for the younger growth stages and whilst not significant, the 2 lb/ac concentration gave a marked overall reduction in plant weight.

Number of heads (Table 5) Significant main effects were obtained for concentration ($P = 0.01$) stage of growth ($P = 0.05$) and cultivars ($P = 0.001$). No significant interactions were recorded. Overall, the greatest number of heads was produced by Sultan and least by Proctor, with Julia intermediate. The number of heads declined with increased concentration of CEPA and with application at younger stages of growth.

Straw length (Table 6) A significant variation in straw length was recorded between cultivars ($P = 0.001$). Straw length was also influenced by the concentration of CEPA applied ($P = 0.001$) and the stage of growth at the time of application ($P=0.05$). Reduction in straw length was most marked when treatments were made at the older growth stages. A significant cultivar/concentration interaction ($P = 0.001$) is explained by the fact that straw length of Julia consistently declined with increased concentration but tended to increase up to 1 lb/a.i./ac with Sultan and Proctor, thereafter declining at the 2 lb/a.i./ac dose.

1,000 grain weight CEPA treatment had no significant effect on grain weight though a marked reduction was noted for the 2 lb/ac treatment. A significant difference was observed between cultivars ($P = 0.01$) the overall yield of Sultan being greatest, followed by Julia and then Proctor.

DISCUSSION

Both the field trials gave disappointing results. There was almost complete lodging at site 2, and none at site 1, so that the effect of CEPA on this important factor could not be ascertained. However, the reduction in yield which was observed would appear to preclude the use of CEPA as a straw shortening agent.

Other phenomena which were observed but not quantitatively assessed included a delay of about 10 days in ear emergence in treated plots at the higher rates, with a corresponding delay in maturity and ripening.

Table 2

Site 2: Thirsk, Yorkshire

Cultivar	Zephyr
Stage of growth at spraying	G-H
Date of spraying	11th June 1969 (Certrol PA applied separately on 12th June 1969)
Date of assessment	6th August 1969
Grain samples taken	12th September 1969

16 treatment combinations of CEPA (4), Nitrogen (2), Wetter (2)

CEPA lb/a.i./ac		Nitrogen units/ac		Wetter (Cit) or herbicide (Cert)	Mean length of tillers cm.	Number of tillers per 10 plants	% Tillers Heading	Mean grains per ear	1,000 grain weight
0	+	60	+	Cit	79.2	54.25	97.4	22.7	37.84
0	+	60	+	Cert	63.9	52.50	95.5	21.0	41.63
0.5	+	60	+	Cit	74.1	64.75	96.3	18.8	38.28
0.5	+	60	+	Cert	69.1	56.50	94.2	22.4	40.64
0.75	+	60	+	Cit	64.6	71.00	92.0	20.9	38.44
0.75	+	60	+	Cert	67.9	59.75	96.8	21.7	34.85
1.0	+	60	+	Cit	62.3	58.00	84.2	20.2	30.12
1.0	+	60	+	Cert	63.0	57.75	85.8	19.7	38.24
0	+	90	+	Cit	70.0	67.50	94.4	21.3	40.88
0	+	90	+	Cert	69.7	55.75	93.2	20.6	39.78
0.5	+	90	+	Cit	69.6	48.50	92.6	19.3	33.91
0.5	+	90	+	Cert	67.1	49.50	93.3	20.9	37.10
0.75	+	90	+	Cit	66.3	58.00	92.5	19.9	35.53
0.75	+	90	+	Cert	64.6	54.25	93.9	19.1	34.50
1.0	+	90	+	Cit	65.7	69.00	80.9	19.7	33.42
1.0	+	90	+	Cert	64.0	54.75	94.8	19.9	33.74
				S.E.	± 4.34	± 10.15	± 4.02	± 1.32	± 2.26

Table 3

The effect of CEPA on the mean number of tillers per plant

CEPA formulation and concentration		Mean number of tillers per plant											
		SULTAN				PROCTOR				JULIA			
		D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J
	0 lb/ac	5.60	3.00	5.30	4.30	3.00	2.10	3.10	3.10	3.00	3.60	4.00	5.00
	0.25	4.00	3.60	4.60	4.30	1.00	2.10	3.60	4.00	3.30	4.60	4.60	6.60
'Technical'	0.5	2.60	3.60	2.60	7.00	1.30	3.00	2.30	3.00	4.30	3.30	5.00	5.30
	1.0	1.30	3.00	6.00	4.30	1.60	2.60	3.60	4.30	2.60	4.00	5.00	4.60
	2.0	2.00	4.00	3.30	6.00	2.00	1.60	2.60	3.30	2.60	2.00	4.00	5.30
	0 lb/ac	2.60	3.00	5.30	4.30	1.30	3.00	4.30	2.00	2.60	4.00	2.50	4.00
	0.25	2.30	2.00	9.00	7.30	2.30	2.00	3.10	4.30	3.50	2.60	3.50	5.00
ACP 68-250	0.5	1.60	3.00	5.00	5.00	2.00	2.10	4.30	4.60	4.60	3.10	2.00	5.30
	1.0	2.30	1.60	3.30	4.30	1.00	1.30	3.30	3.30	3.00	2.60	2.00	4.60
	2.0	1.60	3.00	3.00	3.60	2.30	2.00	3.40	4.00	4.30	1.00	4.00	4.00

Table 4

The effect of CEPA on the mean weight of plant

CEPA formulation and concentration		Mean weight per plant (g)											
		SULTAN				PROCTOR				JULIA			
		D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J
	0 lb/ac	1.36	0.69	1.38	1.11	1.22	0.70	1.05	1.38	0.72	1.53	0.63	1.40
	0.25	0.77	1.15	1.42	2.08	0.50	0.57	1.10	0.91	1.00	0.45	0.86	0.96
'Technical'	0.5	0.67	1.29	0.49	2.99	0.51	1.29	0.67	1.41	1.05	0.83	0.75	1.05
	1.0	0.90	1.89	1.40	1.97	1.23	1.37	1.28	1.19	1.37	0.71	0.79	0.86
	2.0	0.84	1.72	0.79	1.98	0.56	0.84	0.50	0.47	1.62	0.25	1.95	0.54
	0 lb/ac	1.12	1.44	1.49	1.35	0.75	1.01	1.27	0.82	1.19	1.30	1.01	1.61
	0.25	0.86	0.93	2.03	1.89	0.84	0.61	0.94	1.47	1.11	1.20	1.03	1.52
ACP 68-250	0.5	0.68	0.85	1.37	1.55	0.84	0.85	1.51	1.76	1.33	0.89	1.31	2.32
	1.0	0.95	0.69	0.96	1.49	0.81	0.42	0.75	1.16	1.04	1.05	1.38	1.17
	2.0	1.01	0.89	1.08	1.36	0.53	0.49	0.51	1.01	1.00	1.28	0.71	1.20

Table 5

The effect of CEPA on the mean number of heads per plant

CEPA formulation and concentration			Mean number of heads per plant											
			SULTAN				PROCTOR				JULIA			
			D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J
	0	lb/ac	2.00	0.00	2.67	1.67	1.33	0.33	1.33	1.67	1.67	2.33	0.00	2.67
	0.25		0.67	0.67	2.67	3.00	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.00
'Technical'	0.5		0.00	1.67	0.00	4.33	0.00	1.00	0.00	2.33	1.00	1.00	1.00	0.00
	1.0		0.33	2.00	1.33	3.00	1.33	0.33	0.33	0.00	1.33	0.00	0.33	0.00
	2.0		0.33	1.33	0.00	1.33	0.00	0.00	0.00	0.00	1.33	0.00	1.00	0.00
	0	lb/ac	1.67	2.67	2.00	2.67	0.67	0.67	1.00	0.67	3.00	2.33	3.00	2.33
	0.25		0.67	1.67	3.33	3.33	0.33	0.00	0.00	2.00	0.67	1.00	0.67	1.33
ACP 68-250	0.5		0.67	1.33	3.00	1.33	1.00	0.67	2.00	1.67	1.33	1.33	2.67	3.00
	1.0		0.33	0.33	1.33	2.00	0.33	0.33	1.00	1.00	1.33	0.33	1.00	0.00
	2.0		1.00	0.67	0.67	3.00	0.00	0.33	0.00	0.67	0.00	0.00	0.00	0.00

Table 6

The effect of CEPA on the mean straw length per plant

CEPA formulation and concentration			Mean straw length per plant (mm.)											
			SULTAN				PROCTOR				JULIA			
			D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J	D/E	F/G	H/I	I/J
	0	lb/ac	38.37	28.90	33.96	33.59	31.88	40.07	38.47	47.48	34.91	39.36	40.84	36.66
	0.25		29.18	31.97	39.25	45.05	50.83	33.59	47.90	39.21	43.07	27.28	28.81	29.98
'Technical'	0.5		28.21	39.87	32.38	38.37	44.57	44.23	46.66	49.23	30.70	32.75	32.65	33.11
	1.0		55.13	40.17	36.09	45.93	55.70	52.26	43.26	41.52	40.45	38.01	37.15	28.31
	2.0		32.14	34.87	34.67	34.75	28.63	36.16	24.55	19.54	31.97	19.25	46.04	17.51
	0	lb/ac	36.09	42.12	29.41	36.97	46.60	41.79	35.28	47.97	45.13	39.40	33.45	31.54
	0.25		41.14	47.73	33.80	34.60	47.01	33.90	37.02	43.95	37.29	34.61	31.86	34.61
ACP 68-250	0.5		43.70	34.23	31.89	38.49	51.24	44.17	45.38	50.88	33.52	41.46	37.42	38.38
	1.0		42.51	58.08	38.62	39.35	59.20	41.73	36.94	49.16	41.56	30.99	29.88	30.92
	2.0		47.53	37.84	41.00	41.71	32.99	29.63	17.96	34.45	40.97	45.66	27.35	31.61

At the time when the crop was mature, differences in size and orientation of the flag leaf could be observed and, coupled with this, the awns of treated plants appeared shorter. As the ear and flag leaf contribute considerable quantities of dry matter to the grain (Archbold, 1942), these factors could have influenced the final yield in these trials.

The results of the glasshouse trial largely confirm those of the field experiments. Whilst CEPA treatments can reduce straw length and increase tillering, the general reduction in plant weight and grain yield are sufficiently great to be regarded as undesirable from a commercial viewpoint.

The results indicate that formulated CEPA is more effective than unformulated in increasing tillering when applied at the oldest growth stages. This suggests that a limitation in the cuticle penetration of CEPA may play an important part in regulating its effectiveness.

It has been suggested that ethylene increases ATPase activity (Pratt & Goeschl, 1969). If this is the case in barley, then it is possible that at higher concentrations CEPA may inhibit the production of ATP, thus interfering with energy-dependent translocation processes and inhibiting its own movement.

The effect of CEPA in stimulating tillering and reducing straw length may be explained on the basis of the action of ethylene as an anti-auxin. It is also suggested (Pratt & Goeschl, 1969) that ethylene inhibits polar transport of endogenous auxin from the meristems to the regions of cell elongation. If this is the case in barley, then the reduction in straw length by CEPA may be due to an inhibition of auxin movement from the meristem to the regions of elongation, thus inhibiting the normal processes of cell enlargement. Similarly, the increase in tillering may be explained on the basis of the action of CEPA in breaking auxin-controlled apical dominance, the inhibition of polar auxin movements allowing development of the side shoots. This increased tillering probably explains the increase in plant weight resulting from CEPA treatment in certain cases.

Both the number of heads produced and grain yield were adversely affected by CEPA application at a concentration of 2 lb/a.i./ac. This concentration also caused considerable delay in ear emergence and a large reduction in the area of the flag leaf. This could result in a reduction of photosynthesis by the flag leaf and awns resulting in a decrease in grain weight. It is possible that this smaller leaf size is a result of the influence of ethylene on cell size (Funke et al, 1938).

In conclusion, therefore, it appears that under the conditions of the experiment, CEPA is relatively effective as a straw shortening agent but generally decreases grain yield.

Further work is being carried out to examine the effect of applying CEPA at later stages of growth and as different formulations designed to facilitate leaf entry. An investigation of the mode of action of CEPA on barley is also underway to determine the relationship between uptake/movement/metabolism and activity.

Acknowledgments

The authors wish to thank the staff of the Field Development Section of A.H. Marks & Co. Ltd. for their help in the field trials. Also Dr. R.C. Kirkwood of the University of Strathclyde for his helpful criticism throughout the project. One of us (R.B.M.) wishes to acknowledge the provision of a postgraduate studentship by Amchem Products Inc., Ambler, Pa.

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THE EFFECTS OF 2-CHLOROETHYLPHOSPHONIC ACID SPRAYS ON VITIS VINIFERA RELATED TO MECHANICAL HARVESTING

I. Eynard
Istituto Coltivazioni Arboree, Università di Torino, Italy

Summary Treatments with CEPA (1000-2000 ppm) 10 days before harvesting on 'Barbera', 'Sangiovese' and 'Trebbiano' grape varieties reduced significantly the pull force required to remove the berries from the vine, and also caused some defoliation. Sugar content was not significantly affected.

INTRODUCTION

The possibility of completely mechanizing the grape harvest is at present one of the main interests in the viticulture projects of many countries.

One possibility for solving this problem is to find chemicals which promote berry abscission. Among the most promising chemicals at present is 2-chloroethylphosphonic acid (CEPA) also known as Ethrel or Ethephon.

Preliminary studies in USA, indicated that leaf spraying with CEPA (125-500 ppm) near harvest time, hastened berry abscission of 'Concord' grapes (V. labrusca L.).

Further researches by Clore and Fay (1970) confirmed the effectiveness of CEPA foliar treatments for making easier the mechanical harvesting of grapes. To get more information about the reaction of V. vinifera to CEPA, experiments were carried out during Autumn 1969, partly in Avellino and partly in Turin.

METHOD AND MATERIALS

In Turin leaves and clusters of 'Barbera' vines were sprayed with CEPA (*) at 500 and 1000 ppm a.i. 10 days before harvest, using a randomized blocks design with 5 replications.

A comparison was also made between untreated vines and vines treated with CEPA 2000 ppm, replicated only 3 times.

In Avellino CEPA at 1000 and 2000 ppm was tested on 'Sangiovese' and 'Trebbiano' cultivars, using a randomized blocks design with 4 replications. Sprays were again applied 10 days before harvest.

(*) Source of Ethrel 68-240 AMCHEM, Soc. Rumianca, Torino, Italy.

At harvest time berries detaching from clusters after a mechanical uniform shaking were counted; for the shaking a device making 120 swings of 8 cm amplitude per minute was used. Berries with pedicels were counted separately from those without pedicels. Also determined were the sugar content of the juice (by a refractometer) and the pull force for the berries still attached to the grape-stalks, using a De Rosa device (1963).

The following Spring observations were made on bud growth and on May, 19 the lengths of all the new shoots were measured as well the mid cross-sectional area of the branches.

RESULTS

Though 500 ppm CEPA treatment significantly increased the abscission of 'Barbera' berries after shaking, the best results were obtained with 1000 and 2000 ppm (Table 1).

In Avellino both 1000 and 2000 ppm treatments increased 'Sangio' vese' abscission while 'Trebbiano' was significantly affected only by the higher concentration (Table 2).

Table 1

% Berry abscission after shaking (cv. 'Barbera')

Treatments		without pedicels	with pedicels	total
control		5,71	0.73	6.44
CEPA 500 ppm		14.09	1.33	15.42
CEPA 1000 ppm		29.82	4.80	34.62
LSD	P = 0.05	6.36	4.18	7.79
	P = 0.01	9.26	6.08	11.33
control		11.00	5.51	16.51
CEPA 2000 ppm		22.20	19.19	41.39
LSD	P = 0.05	5.48	25.02	21.43
	P = 0.01	12.64	57.71	49.46

Table 2

% Berry abscission after shaking (cvs. 'Sangiovese' and 'Trebbiano')

Treatments	without pedicels	with pedicels	total
'Sangiovese'			
control	16.87	0.78	17.65
CEPA 1000 ppm	35.25	0.51	35.76
CEPA 2000 ppm	42.77	1.00	43.77
LSD P = 0.05	12.08	1.05	11.58
P = 0.01	18.29	1.59	17.54
'Trebbiano'			
control	10.80	2.37	13.17
CEPA 1000 ppm	9.82	1.69	11.51
CEPA 2000 ppm	22.20	3.83	26.03
LSD P = 0.05	9.42	2.31	10.75
P = 0.01	14.28	3.50	16.29

The higher abscission rate is not accompanied by significant reductions in sugar content.

The pull force needed to detach the berries still remaining on the stalk after shaking, is only slightly and not significantly lower than the untreated plots with 'Trebbiano' and 'Sangiovese' (1000 and 2000 ppm) and 'Barbera' (500 and 1000 ppm). Only 'Barbera' treated with 2000 ppm CEPA gave highly significant results.

CEPA treatments have been observed to hasten leaf drop. Ten days after spraying, 'Barbera' treated with 500 ppm CEPA was showing a high rate of defoliation, while in untreated vines leaf drop was hardly started; with 2000 ppm, defoliation was almost complete, especially close to the clusters.

Observations on shoots during Spring 1970 showed no bud damage, but the growth rate of shoots seemed to be slightly reduced by all CEPA treatments. The differences however were not significant at P=0.05.

DISCUSSION

The different effects obtained in Turin and Avellino could result from differences in cultivars or environmental conditions. Temperature after treatment can strongly influence the abscission phenomenon.

According to Clore and Fay (1970) an average daylight temperature of 18.8°C (65°F) is necessary in order to get 50% berry abscission of 'Concord', using CEPA sprays of 250 ppm or higher concentrations.

Our average temperatures between spraying and harvesting were slightly higher for 'Trebbiano' than for 'Barbera' and 'Sangiovese'.

The daylight temperatures were much lower in Turin, where only one day out of ten, the average was higher than 18.8°C. In Avellino we had higher temperatures, with respectively 8 and 9 days out of 10 over 18.8°C. There results do not confirm Clore and Fay's conclusions, but we must not forget they worked with a different Vitis species.

Autumn treatments of CEPA can increase berry abscission of V. vinifera: this is a good reason for further investigations in order to get better answers for a complete mechanical grape harvesting.

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GROWTH RETARDATION ON LAWNS WITH CHLORFLURENOL

J. Berker, O. Hierholzer and H. Friedländer
E. Merck, Darmstadt

Summary Tests have been carried out for some years with several mixtures of chlorflurenol with maleic acid hydrazide as a growth retardant for lawns. Results obtained show that it is possible to inhibit most commonly used grass species for 4 - 5 weeks without any unacceptable side-effects.

INTRODUCTION

Chlorflurenol (common name for 2-chloro-9-hydroxyfluorene-9-carboxylic acid) belongs to the Morphactins, a group of novel compounds, the growth regulating properties of which were discovered in the Research Laboratories of E. Merck, Darmstadt.

Derivatives of chlorflurenol proved very effective as inhibitors of plant growth. A product based on the methyl ester of chlorflurenol is available commercially under the name of CF 125*. This is being used in combination with maleic hydrazide (MH) for growth retardation of extensive grasslands along roadsides, on centre reservations of motorways, airports, military training grounds, depots etc.

At the last British Weed Control Conf. 1968 a paper was given on chlorflurenol (Berker et al, 1968). This year Schneider and Mohr (1970) will present a survey on the most interesting properties of morphactins and Stahler and Harris (1970) will report on their experience gained in woody growth control.

The use of chemical growth retardants on grassland is to save labour on mowing. This is of primary interest during the holiday season when, particularly on motorways, traffic is very heavy. Because during this period of time mechanical cutting would be too dangerous, there is a demand for chemicals to control growth of grasses and weeds in order to keep verge indicating posts free. Here a possible discolouration of vegetation is of some but only minor importance.

Conditions are quite different on lawns around houses, in parks etc., where the standard of appearance is much higher and marked discolouration is not considered acceptable.

With regard to duration of the inhibiting effect, requirements also vary greatly. Whilst for extensive sites in most cases inhibition is only of interest that lasts for months, on lawns even a few weeks are attractive. Extensive grasslands are most successfully inhibited when they are treated in spring shortly after growth begins. For lawns

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* Trade-mark E. Merck, Darmstadt

this date is only exceptionally of interest e.g. when with municipalities a labour shortage exists at the beginning of the season.

For small lawns in private gardens it will always be of interest t retard growth when regular mechanical cutting has to be interrupted e. due to absence during vacations. A great many home gardeners will have experienced difficulties in mowing their lawns on return from holidays

As was described in detail (Barker *et al*, 1968) chlorflurenol lead to dwarfing of treated plants. This effect is particularly clearly sho by dicotyledonous weeds. With grasses length of leaves is reduced and formation of flower stalks is prevented. The latter, however, require much higher doses as compared to dicotyledons. The spectrum of activit of chlorflurenol with grasses differs remarkably from that of MH. This is why combinations of these two active ingredients proved particularl promising for mixed stands of various grass species. At the same time chlorflurenol gives satisfactory inhibition of broad-leaved weeds.

METHOD AND MATERIALS

Initial experiments with various combinations of chlorflurenol and MH showed that, especially with regard to grass tolerance, only certai formulations deserved further interest.

Both in 1969 and 1970 trials were conducted with several mixtures sites with defined stands of grasses and on lawns where over a period of years, a local sward had developed.

The turf seed mixtures used in both years had the following composition:

I. 35 % *Poa pratensis*-Merion
15 % *Poa pratensis*-Newport
50 % *Festuca rubra*-Pennlawn

II. 30 % *Poa pratensis*-Newport
20 % *Poa pratensis*-Arista
40 % *Festuca rubra*-Topie
10 % *Agrostis tenuis*-Astoria

III. 85 % *Festuca rubra-fallax*
15 % *Agrostis tenuis*-Astoria

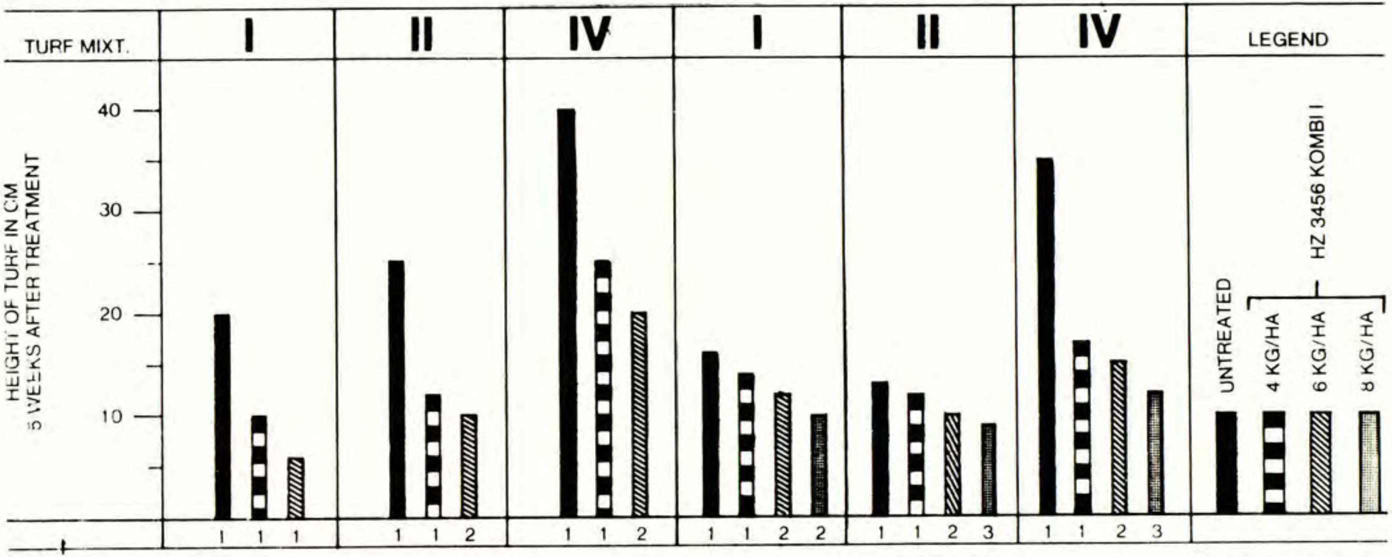
IV. 50 % *Festuca rubra-fallax*
30 % *Poa pratensis*
15 % *Lolium perenne*
5 % *Agrostis tenuis*

The products CF 125 and MH are identical with those available commercially. HZ 3456 Kombi I is a wettable powder, HZ 3456 MH III a dispersion. Both are experimental products containing both chlorflurenol and MH in different ratios.

RESULTS

In Fig. 1 results are presented of a trial carried out in 1969 wit various rates of a combination of chlorflurenol and MH coded HZ 3456 Kombi I. Further examples of trials results are given in Figs. 2 and

The inhibitory effect is most clearly seen in fast-growing species such as *Lolium perenne*. There exist also varietal differences (Kern,1 which again have been particularly marked in *Lolium perenne*. Among the grass species that are common on lawns *Poa trivialis* reacts readily ar under certain conditions even proves susceptible (Hierholzer, 1969).



WORST COLOUR
DURING 5 WEEKS
AFTER TREATMENT

TREATMENT ON
APRIL 2, 69 AT
START OF GROWTH
BEFORE FIRST
CUTTING

TREATMENT ON
MAY 28, 69
IMMEDIATELY
AFTER FOURTH
CUTTING

RATING OF COLOR
1 = UNTREATED
5 = TOTAL AREA
MARKEDLY
DISCOLOURED

FIG. 1

GROWTH RETARDATION OF VARIOUS
TURF MIXTURES AT DIFFERENT DATES
WITH HZ 3456 KOMBI I

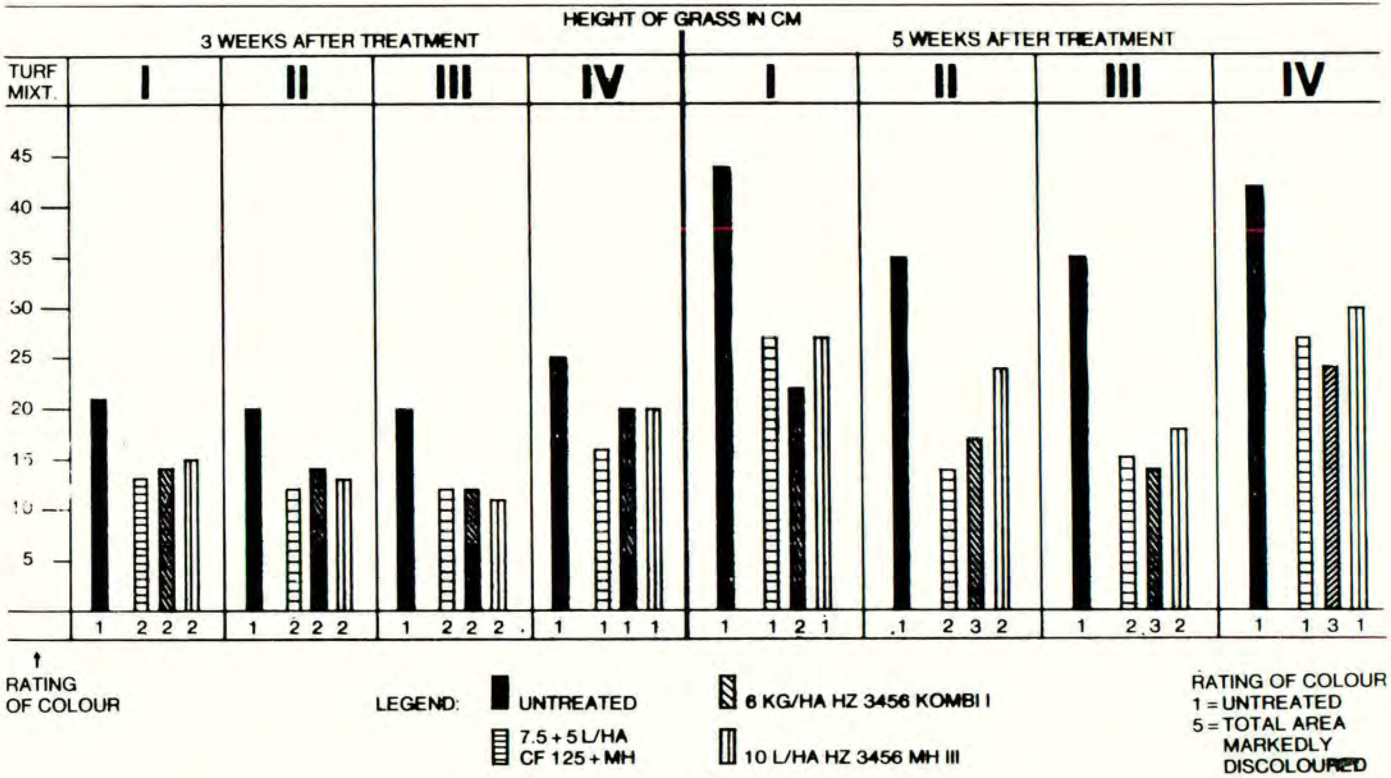


FIG. 2

GROWTH RETARDATION OF VARIOUS
TURF MIXTURES WITH 3 COMBINATIONS
DATE OF TREATMENT: MAY 19, 1970

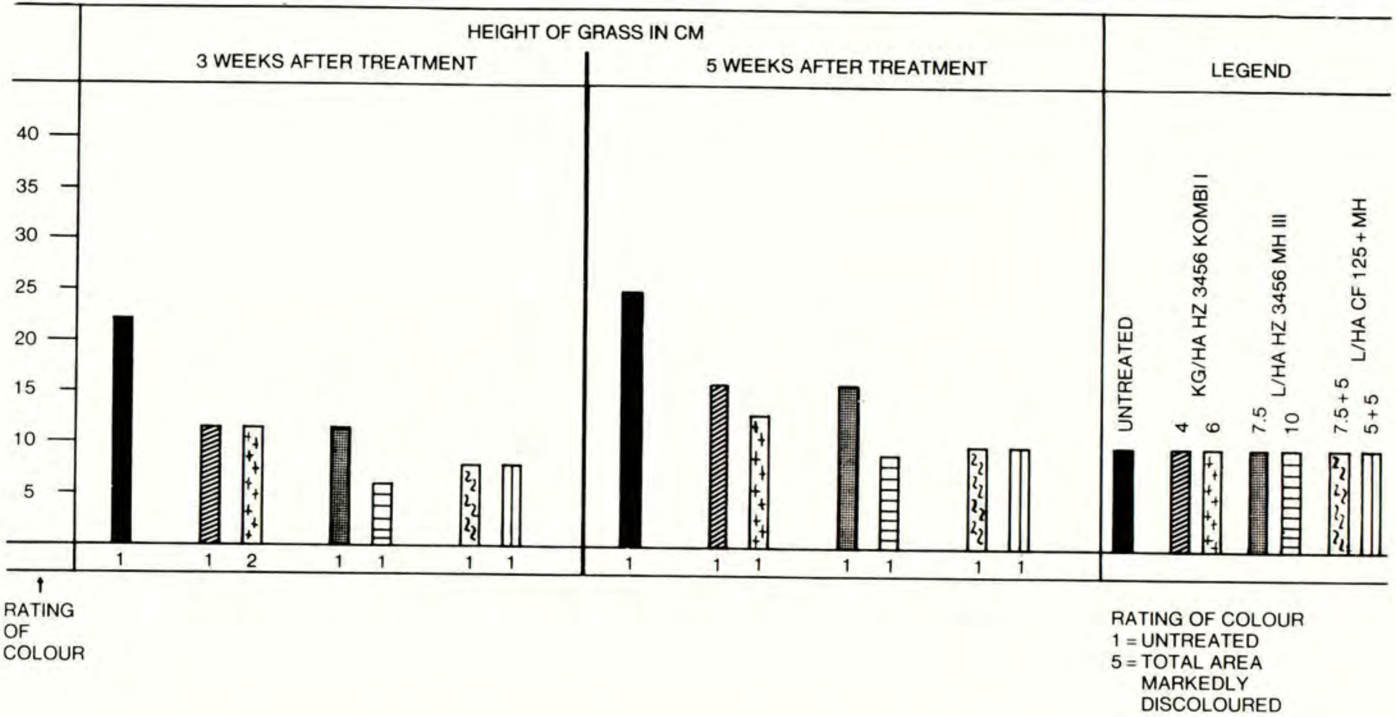


FIG. 3

GROWTH RETARDATION ON LAWNS
WITH MIXTURES OF CHLORFLURENOL AND MH
DATE OF TREATMENT JUNE 10, 1970

DISCUSSION

As a result of several years trials with chlorflurenol combination on lawns, i.e. intensively managed turf, the following statements can be made:

1. The desired growth retardation on lawns of about 4-5 weeks duration can be achieved with dosages of about 700-2000 g/ha chlorflurenol and 1500-3000 g/ha MH depending on the formulation and growing conditions. At these rates grass tolerance is satisfactory.
2. The effect becomes visible about 4-8 days after treatment.
3. Spraying should be as uniform as possible. For this purpose a spray boom with several nozzles, preferably flat spray nozzles, has been successfully used. Watering cans with roses proved inadequate. Experiments to develop a simple but reliable device are under way.
4. Discolouration can occur in case of overdosage on extremly poor and dry sites. Only very high doses, however, will result in irreparabl damage.
5. Prior to treatment the following should be observed:
   a) No fertilizer should be used shortly before a growth retardation treatment.
   b) When choosing the rate, it should be considered whether growing conditions are favourable or not. On dry, poor soils grasses may show discolouration whilst on better soils they prove tolerant of the same concentration.
   c) A sufficient leaf surface is necessary to make sure that enough active ingredient is taken up. This is why prior to treatment grass should not be cut shorter than usual. For lawns where longer mowing intervals (8 days and longer) are parctised, it proved advisable to delay the treatment for 1-4 days after the last cutting.
6. After a period of growth retardation it is recommended to irrigate and to apply nitrogen.
7. The first mowing after a period of growth inhibition usually result in a more intensive green appearance of the lawn as compared to untreated. On untreated sites the individual grass is cut in the leaf sheath region whereas on treated plots the cut as a rule runs throug the blades of the leaves.
8. Grass retardation with chlorflurenol combinations also gives some degree of weed control and inhibits the formation of seed heads of _Poa annua_.

CONCLUSIONS

Results of trials obtained so far show that chlorflurenol in combination with MH allows growth of lawns in parks and in private gardens to be inhibited for 4-6 weeks and that:

a) during this period of time the appearance of treated sites is no spoiled
b) after this period of time efficient lawn mowers of all types can be used, and
c) once the effects of the growth regulators have disappeared treated grass continues growing at a normal rate.

We are convinced that such a product can fill a gap, in particular because it enables owners of small gardens to go for holidays and to leave their lawn on its own for several weeks.

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WOODY GROWTH CONTROL DEVELOPMENTS WITH CHLORFLURENOL IN NORTH AMERICA

L. M. Stahler and G. K. Harris
Agricultural Research and Development Department
U. S. Borax Research Corporation
Anaheim, California, U.S.A. 92803

Summary U. S. Borax Research Corporation has from 1967 undertaken extensive investigations to determine the efficacy of chlorflurenol* in the form of its methyl ester (methyl 2-chloro-9-hydroxy-fluorene-9-carboxylate) in controlling the growth of woody vines, shrubs and trees. Over 200 woody species have been included in these tests in the United States and Canada.

Accumulated data indicate that use of chlorflurenol in several test formulations is highly practicable in managing growth of many woody plant species at rates of application far below those established for control of growth of grasses. General recommendations have been worked out for the major woody plant categories.

The most important economic applications are for retarding growth of trees growing under, or adjacent to, power and communication cable lines; controlling growth of trees, shrubs and vines in areas adjacent to highways; maintaining trees, hedges and ornamental shrubs in parks, playgrounds, military installations, cemeteries, and home gardens.

INTRODUCTION

U. S. Borax Research Corporation first tested chlorflurenol in late 1966 as a growth retardant for turf grasses. These initial tests, based on work previously done by E. Merck, showed this compound to be an effective and highly versatile growth regulator with an amazing ability to control broadleaved herbaceous species commonly infesting turf grass areas. Continuing this work, in early 1967 we noted that occasional woody shrubs contacted with this material also showed a marked growth response and, in order to confirm this action, we uniformly treated approximately 50 species of ornamentals common to the Los Angeles, California, area with a water spray solution containing 100 ppm, a.i., of chlorflurenol. These were small plantings - one to two feet in height - growing in one-gallon containers. This early investigation gave marked reduction without undesirable growth defor-

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* A product of E. Merck, Darmstadt, West Germany

mity on more than 50 % of the species and confirmed that chlorflurenol would, in fact, have a high potential for commercial use in controlling the growth of woody plant species.

METHOD AND MATERIALS

During the growing season of 1967, and continuing through this current season, we have expanded these investigations to include approximately 200 species of trees, shrubs, and woody vines of commercial importance over the United States and Canada. Efforts in the past four years have been devoted to determining the most efficient methods of application of chlorflurenol and the most effective dosage rates. Test rates have varied from 10 to 1,200 ppm in water spray solution. A great deal of progress has been made toward establishing the most efficient combination of factors necessary for a maximum of growth control without producing undesirable growth effects, and over-all to establish the practicability of chlorflurenol for control of woody plant growth on industrial sites, on boulevards, in parks, and for the home gardener.

These tests have involved in excess of 5,000 individual trees, shrubs, and vines, representing species indigenous to the test areas or horticulturally adapted species widely used in the various areas of tests.

Remarkably, in our test programs, using water spray solutions as foliar treatments, we have in no case killed trees, shrubs, or woody vines and, even where excessive rates have produced seasonal injury, plants have eventually recovered.

RESULTS AND DISCUSSION

Foliar spray application

Of the various methods of applying chlorflurenol to woody plants, use of a water spray solution as a foliar application has been most consistent in giving one or more seasons of effective growth retardation. This method of application, which at first would appear most practicable, has limitations - especially in one of the major areas of use in North America, where people have become highly conscious of the drift and volatility effect of compounds such as 2,4-D and 2,4,5-T. For public relations reasons, power and communications companies, or industrial tree trimmers that they normally employ, are at this time reluctant to be conspicuously associated with operations that involve power spray equipment, even though chlorflurenol presents minimal hazards from drift and zero hazards from volatility, and has broad clearance from Government regulatory agencies in both Europe and North America insofar as warm blooded animals are concerned.

The use of chlorflurenol at 200 to 400 ppm in water spray solution sufficient to wet the foliage has given evidence of good growth control on a wide range of species without adverse reaction from the public to the browning produced by some older chemicals. Chlorflurenol, while stunting the growth of the unwanted vegetation, retains the green colour.

In other areas the public relation factor is less important and chlorflurenol can be used without any comment. This is well illustrated in the quite wide use of chlorflurenol along the vast freeway system in Southern California, where heavy plantings of shrubs and vines are employed as ground cover to beautify the roadsides and as a sound barrier for the protection of urban residents living adjacent to these freeways.

In our extensive investigations on the use of foliar sprays, it has been found that genera and species vary considerably in their reaction to dose levels of chlorflurenol. In general, applications of water spra solutions of 150 ppm to 300 ppm are most efficient in giving maximum growth reduction. However, Algerian ivy (Hedera canariensis) requires 600 to 1,200 ppm, and Hahns (English) ivy (Hedera helix) only 100 to 200 ppm for effective retardation. A marked exception to the general tolerance of woody species has been established for the genera and species of Gymnospermae found throughout the United States and Canada, suc as Pinus spp., Juniperus spp., Picea spp., Abies spp., and Pseudotsuga spp. which are most efficiently treated with 50 ppm to 100 ppm. Further with this group, our investigations have indicated that spray applications should be applied either early in the season before the growth buds expand into so-called "candle" form, or after maturation of this new growth. Treatments made during the expansion and maturation period may result in marked reaction - in some cases causing a very abnormal appearance.

Table 1

Representative genera of woody vines, shrubs and trees and concentration of chlorflurenol in ppm, a.i., in water spray established as most practicable in growth control studies - United States and Canada - 1969-1970

Genera	Efficient rates of application of chlorflurenol	Genera	Efficient rates of application of chlorflurenol
Vines:		Shrubs:	
Hedera canariensis	600-1,200 ppm	Nerium spp.	400-600 ppm
Hedera helix	100- 200 ppm	Acacia spp., Elaeagnus spp., Plumbago spp.	150-300 ppm
Trees:			
Acer spp., Fraxinus spp., Ulmus spp., Quercus spp., Platanus spp., Salix spp.	200- 300 ppm	Prunus pissardii, Crataegus indica	75-150 ppm
		Buxus spp.	25 ppm
Pinus spp., Juniperus spp., Picea spp., Abies spp., Pseudotsuga spp.	50- 100 ppm		

Table 1 presents data indicating range of chlorflurenol concentration most efficient in controlling growth of a selected list of genera and species common to North America. In treating deciduous trees or shrubs, timing of application is also important. Most efficient retardation is secured when treatments are made after the first flush of spring growth has developed mature leaves. Treatment of immature growth in early spring, results in epinastic response of terminal growth that may be evident throughout the growing season.

Species vary considerably in the period of reduced growth, or response, following foliar spray. Many show marked effects in the second season following treatment. In others, the major effect is evident during only one season of growth. With shrubs used as hedge plantings, where repeated hand trimming is usually practised, a full season of satisfactory retardation is generally not secured. However, 8 to 12 weeks of satisfactory retardation has been secured on such hedge species as Elaeagnus and Euonymus (Table 2). Hedges are most satisfactorily treated immediately after the first spring trimming and before regrowth appears.

Table 2

Growth response of several species of hedge shrubs treated after first hand trimming in spring of 1970, Chattanooga, Tennessee, with water spray containing 300 ppm, a.i., chlorflurenol

Species	Application date	Evaluation dates	Appearance	Average % Retardation	Control Average**
Elaeagnus angustifolia	4-6-70	5-25-70	S*	97	3 1/2 in.
		6-15-70	S	97	4 1/2 in.
Euonymus patens	4-6-70	5-25-70	S	97	6 in.
		6-15-70	S	97	9 in.
Jasminum floridum	4-6-70	5-25-70	S	93	10 in.
		6-15-70	S	93	10 in.

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* S = Satisfactory
** Average length of new growth control

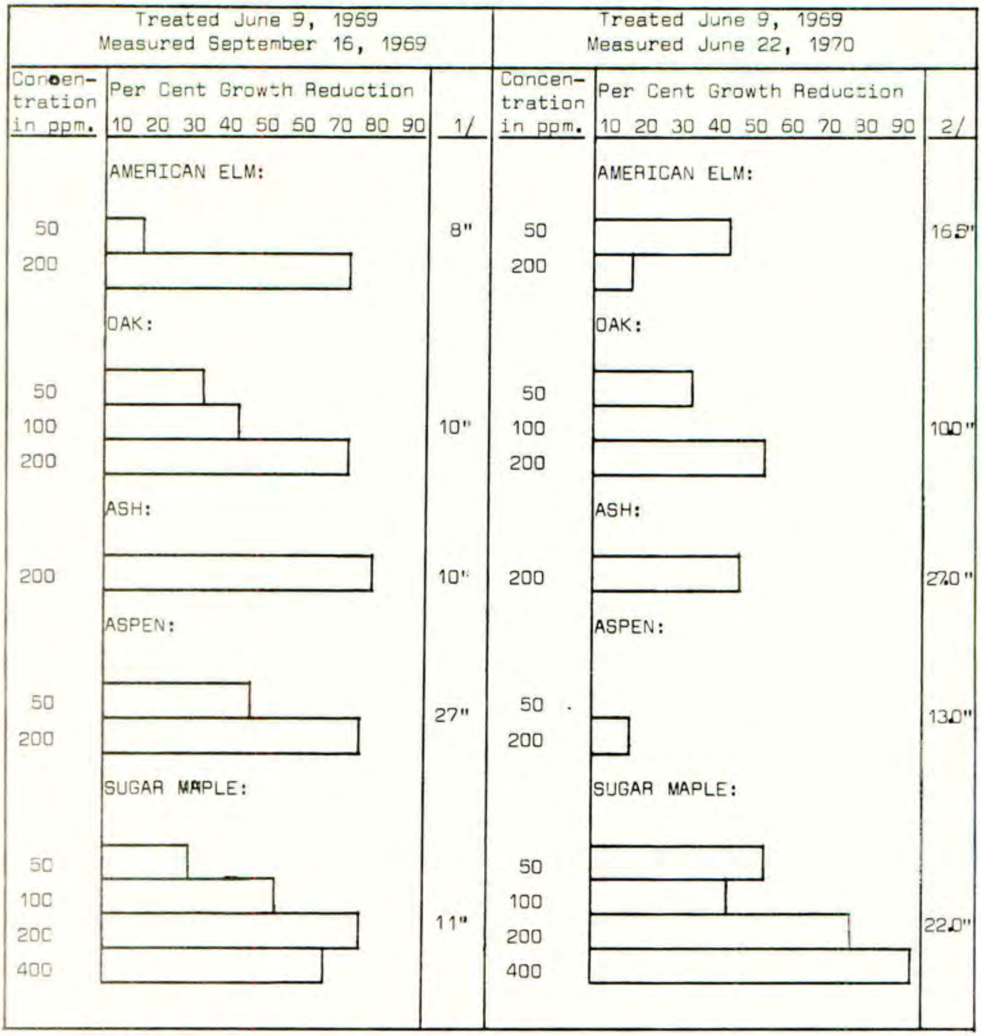
Uniform application, using sufficient spray volume to thoroughly cover all green vegetation, is essential in controlling the growth of woody plants with chlorflurenol. This material in our experience has shown little indication of lateral or basal movement within the woody plant, moving primarily towards the apex. Limited experience has shown that mist blower application of the water spray solution with small back-pack equipment or large truck-mounted equipment will give the most uniform desirable response.

Figure 1 summarizes the effect of various rates of application of chlorflurenol, on a number of common native species of hardwoods, in our investigation in Quebec in cooperation with Quebec Hydro in 1969 and 1970.

Asphalt emulsions

Throughout our area of interest, commercial tree trimming workers commonly use some type of paint on the exposed wood following trimming and cutting operations. This is an established practice to protect the exposed live wood surface from invasion by diseases and insects, to promote faster healing and, further, to improve the appearance of the tree after trimming. In general, cut surface two inches in diameter or larger are painted with an asphalt emulsion.

The cut cambium layer will normally develop a callus covering the edges of the cut surface and, at this point, most hardwood species develop adventitious buds which produce a ring of new shoot growth. In Fraxinus, Acer, Salix, and Carya it is not uncommon to have new shoots develop 6 to 8 feet of growth in a single growing season.



1/ Average length in inches of seasonal growth, 1969 – untreated.

2/ Average length in inches of seasonal growth, 1970 – untreated.

Fig. 1

Effect of chlorflurenol (MAINTAIN® CF 125) at selected concentrations in water solution applied as foliar spray to several hardwood deciduous native tree species near Hull, Quebec, Canada, in cooperation with Quebec Hydro – 1969–1970

In our investigation of means and methods for employing chlorflurenol to limit this type of growth, we have used a number of formulations. These have included invert emulsions,and various grades of asphalt emulsions. The invert emulsions would not properly cover and protect the freshly cut surface and, in some cases, appeared to inhibit normal callus formation at the cut surface.

The most successful formulations have been the asphalt emulsions. We have widely tested both an asphalt paint, applied with a paint brush at time of cutting, and a lighter asphalt emulsion applied from a spray can, pressurized with FREON or similar propellent. Concentrations of chlorflurenol from 0,25 % to 1 %, a.i., have been tested and our quite massive data would indicate no advantage in going beyond the 0,25 %, a.i. concentration. The 16-ounce pressurized spray can is by far the most acceptable to the commercial tree trimming industry.

Chlorflurenol, applied in the manner described here, is again characterized by showing apical movement in the normal sap stream of a plant and, in general, no retardation of sprout development and growth has been observed more than 12 inches below the cut surface on which the chlorflurenol asphalt emulsion has been applied. Some apical movement is indicated by lack of sprouts above the treated cut area if the cut is flush with an upright limb or the main trunk of the tree. Reduction in number of sprouts and length of sprout growth, where chlorflurenol was used in this manner by commercial tree trimmers in field tests, has been consistent.

Asphalt/chlorflurenol formulations for cut surface treatments will be widely marketed in the United States and Canada in 1971.

Other formulations tested

Over the past three years, we have thoroughly investigated the possibility of soil applications of chlorflurenol. Results have been almost wholly negative due to the fact that chlorflurenol has very low solubility in soil-water solutions.

As a possible substitute for foliar applications of chlorflurenol, we have tested a number of formulations in solvents that readily penetrate even the heavy bark of such trees as oak. These formulations are highly promising as the treatment is easy, fast and unnoticable when used in conjunction with regular pruning practices. They permit treating near the base of the trees with further apical movement in the transport stream carrying the chlorflurenol to all the growing points above the site of application. Theoretically they will permit selective treating of large branches of trees so developing that they interfere with power and communication cables, without affecting the growth on the opposite side of the tree and thus maintain desirable growth habits. While these methods appear to be entirely practicable, we have had only one season of field testing and further evaluations are necessary to establish commercial acceptance.

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MORPHACTINS, - A BREAKTHROUGH TO NOVEL TARGETS IN PLANT GROWTH REGULATION

G. Schneider and G. Mohr
Research Laboratories, E. Merck, Darmstadt, W.Germany

Summary This survey outlines the present status and possible future development in the utilisation of morphactins. These new-type regulators are increasingly indicating a breakthrough in wide-scale control of plant growth.

INTRODUCTION

Derivatives of fluorene-9-carboxylic acids (morphactins) cause profound changes in plant growth (Schneider 1964, 1969 a). Since about 1964-1965 interest in these substances has been stimulated through the work of the Merck research group at Darmstadt, West Germany (Mohr et al. 1967, Schneider et al. 1965, 1967). The fundamental results of world-wide research in this field were summarised and discussed recently (Schneider 197o a). The chemistry of these substances is described by Mohr et al. (1967) and Mohr (1969).

The morphactins have low mamalian toxicity (LD 50 after oral administration > 5000 mg/kg body wt.) and are rapidly metabolised in plant and soil, thus presenting no residue problems. They are active on plants over a wide concentration range, producing transient growth inhibition from which the plants recover and regain normal growth. The duration of this effect depends on the dosage applied.

In this report several lines of development with morphactins are stressed which are expected to result in a breakthrough in the scope of chemical control of plant growth. This present knowledge is the result of cooperative work initiated 1965 by the Merck group at Darmstadt with teams in North America (U.S. Borax Research Corp., Anaheim, Calif.) and in other parts of the world (E.Merck 1965-1970).

RESULTS

Growth inhibition/retardation of plants on non-cropped land.

Application of growth regulators is aimed at cutting down mowing, cutting and/or trimming costs. In this increasingly important field (Goodin 1970) chlorflurenol methyl ester - one of the morphactins - has found wide acceptance as a promising new "chemical tool" (Berker et al. 1968, Goodin 1970, Harris 1970). Its broad species spectrum, covering dicots, monocots and including most woody species, in conjunction with the unique tolerance shown by plants towards it places this growth regulator in a position of prime importance in all the situations where vegetation is to be maintained but maintenance costs are to be minimised (Goodin 1970).

Inhibition/retardation of mixed vegetation, e.g. along highways, slopes, ditches, airports, military fields, depots etc. (reference: E. Merck 1965-1970, 1970).

Chlorflurenol (commercial product "CF 125") has proved reliable in European and overseas countries, preferably as a mixture (tank mix) with maleic hydrazide (MH) (Berker et al. 1968, Harris 1970, Stryckers and van Himme 1969, Switzer and Brown 1968, 1970). A report presented to this conference in 1968 concerns itself with these mixtures and their superiority to the older mixtures of MH + phenoxy weed killers. Mixtures of chlorflurenol and dalapon have also quite recently become of some practical importance on more extensive grassland areas. Using chlorflurenol mixtures applied once in spring a season-long growth inhibition can be achieved (Berker et al. 1968).

Inhibition/retardation of woody plants (trees, shrubs and hedges).

In this field chlorflurenol has considerable possibilities for chemical growth control (Harris 1970, Stahler and Harris 1970, E. Merck 1965-1970). MH tested in previous years was almost rejected because of its narrow species spectrum (Goodin 1970). Unlike the arboricides 2,4,5-T or picloram, chlorflurenol will inhibit the growth of trees and shrubs from several months up to a whole year - even under tropical humid conditions - so reducing to a large extent the cutting and trimming procedures along main streets, under telegraph and power lines etc. (Harris 1970, Stahler and Harris 1970).

What is true for inhibition of woody plant growth in landscape locations holds in principle for ornamental hedges. Here, however, a considerably higher standard of appearance is desired, and different species of shrubs respond very differently in this respect. Optimal timing of treatment is of great importance. Development in this field was mainly in the U.S. and Canada by U.S. Borax Research Corporation (Stahler and Harris 1970).

Inhibition/retardation of lawns (home, park and sports).

Lawns normally require intensive maintenance efforts by fertilisation, watering, weed control and, above all, frequent mowing, so that their conventional maintenance in industrialised countries with rapidly rising labor costs becomes an increasing problem (Goodin 1970). Intensified development effort over the past years resulted in experimental preparations based upon special derivatives of chlorflurenol and of MH, by means of which it is now possible for the first time to get a sufficient growth retardation on lawns for up to 5 weeks whilst safely retaining a satisfactory appearance - in effect - a kind of "holiday lawn stop" (Berker et al. 1970, Harris 1970).

Maintenance of soil cover vegetation in perennial crops.

A chemically dwarfed plant cover for protection against erosion by wind and water, for water balance, for improvement of soil shadowing and for some organic matter supply to soils is of widespread interest in perennial tree crops and has become an actual possibility due solely to morphactins (Kadisch 1969, Schneider et al. 1967, Schneider 1969 b). In Europe trials with chlorflurenol and with chlorflurenol +

MH were started mainly on vineyard slopes (Kadisch 1969) and in orchards. Basic research on retardation and morphological/physiological criteria of a series of "green manuring" species over several years is in progress (Steinberg 1970). Similar trials are being carried out in tropical tree plantations (E. Merck 1965-1967).

Broad-spectrum weed control in cereals and field corn.

Synergism between morphactins and phenoxy auxins (Schneider 1964, Schneider 1970 b) is the basis for the development of combination products with extraordinary broad species spectra against the dicotyledonecus weeds in cereals (Schneider and Flemming 1965, E. Merck 1970). These broad-spectrum herbicides based upon flurenol + MCPA allow the control of such diverse types of weeds as Stellaria, Galium, Galeopsis, Polygonum, Sinapis, and Matricaria by only one preparation ("Aniten", "Aniten M"). Not all the weeds, however, are killed. Some are dwarfed to a kind of inhibited and almost beneficial soil cover (Schneider and Flemming 1965).

The importance of morphactin-based herbicide mixtures lies not merely in their broad species spectrum but also in their outstanding efficacy against Galeopsis tetrahit (Hemp nettle). Because of this they are well suited as alternatives for the mixtures containing 2,4,5-T (E. Merck 1970).

Compared to benzoic acid herbicides (see e.g. Fryer and Evans 1968), the morphactin-based herbicides have the advantages of a) no residue problems (Erdmann et al. 1967, Wotschokowsky 1970), and b) a remarkably mild action on cereals (Maas 1968, Weigand 1968).

Add to this the excellent effect on Galeopsis by the morphactin + MCPA preparations and we have clear indication of some superiority of those products as compared to ioxynil and more so to bromoxynil and the mixtures of these benzonitriles + phenoxy auxins (e.g. ioxynil + dichlorprop) (see Carpenter 1968). There is, on the other hand, no comparable effectiveness against Matricaria having more than 4-6 leaves. With the development in recent years of "3 substance mixtures" based on morphactin + MCPA + ioxynil the weak points mentioned above for both groups of herbicides were fully overcome (E.Merck 1965-1970). A flurenol + MCPA + ioxynil preparation introduced in 1969 on the German market ("Herbizid 6o38") is a product of increased herbicidal effectiveness covering a completed range of broad-leafed weeds and of excellent cereal tolerance, representing a new standard in the control of broadleafed weeds in cereals. Experimental preparations of this "3 substance type" containing another morphactin and/or other contact-type components are currently in progress (E.Merck 1965-1970).

In Central Europe MCPA proved to be the safest phenoxy compound for mixing with morphactins for use in cereals. A similar conclusion was reached for 2,4-D for use in Southern Europe and on corn (flurenol + 2,4-D, commercial product "Aniten D") (E.Merck 1970).

Finally experience was accumulated over several years that under more arid conditions morphactin + phenoxy type products (flurenol + MCPA, flurenol + 2,4-D) could effectively control Apera spica-venti, one of the most important grassy weeds found on light sandy soils (Ubrizsy 1969).

Grassland improvement and weed suppression on meadows and pastures.

In meadows and pastures broad-leafed species are thought desirable only up to a limit. A reduction of these species is quite often necessary, and such "improvements" were achieved in the past by phenoxy herbicides. By means of chlorflurenol it now looks possible to limit and gradually repress the number of dicots without the severe loss in yield which is unavoidable with the use of conventional herbicides (Boeker 1969, E.Merck 1965-70, 1970). The morphactin shifts the competition between the species of the grassland association in favor of the grasses, which gradually force back the dicots. This new type of "grassland management" with chlorflurenol is clearly superior to the "hard" use of herbicides adopted so far. It is important that chlorflurenol acts strongly on a range of problem dicotyledoneous perennials such as Anthriscus, Heracleum (Boeker 1969), Conium, Urtica, Pueraria (Kudzu) and, to some extent, Rumex spp. (E.Merck 1965-1970). Results obtained so far indicate an almost complete elimination of these weeds following repeated spraying with chlorflurenol. Against Rumex spp. mixtures of chlorflurenol + mecoprop are reported to be giving good results (E.Merck 1965-1970, 1970).

Weed suppression in lawns.

The repression effect on dicots outlined above for grasslands applies equally well with lawns. As a most desirable "side-effect" grass retarding dosages of chlorflurenol and chlorflurenol + MH completely suppress typical lawn weeds such as Taraxacum, Leontodon, Plantago, Ranunculus and Bellis (Berker et al. 1970, Boeker 1969, Harris 1970, Stryckers and van Himme 1969, Switzer and Brown 1968, 1970, E. Merck 1965-1970). With Poa annua seed production seems to be reduced (E.Merck 1965-1970).

"Puzzling" the weed seedlings in soil and water by chlorflurenol, - a novel concept in weed control.

It is well known that morphactins almost completely inhibit the geotropic and phototropic reactions of plants and thereby abolish any normal directed growth (Khan 1967, Schneider 1964). Following application in the soil (incorporated) or in water (dispersed as granules) morphactins prevent or retard the "surface directed" growth of seedlings or emerging storage organs. Moreover, the substances interact also in some other way inhibiting and modifying development and growth as was shown e.g. for Cyperus rotundus (Rehm 1969). By incorporating chlorflurenol into the soil the emerging vegetation could be suppressed to a considerable extent (80-90%), but could not be prevented. A novel concept being followed up is to what extend weed control in soil and/or water can be improved by joint use of chlorflurenol + certain herbicides. The former causes the germinating or emerging plant stages so as to be retained longer in the medium and, in this way, to be attacked more efficiently by the herbicide.

Growth regulation in tree crops, field crops and ornamentals (reference: E.Merck 1965-1970, 1970).

In fruit trees breaking of alternate bearing is being tested in Malus, and Pyrus, preliminary results indicating some influence of morphactins on the differentiation of fruit buds (Buban et al. 1969, Stankovic et al. 1969). A positive result on flowering and fruit yield in Fragaria was reported but could not be reproduced up to now. Fruit thinning and improvement of fruit quality is aimed for with *Prunus* and *Malus* (Stankovic et al. 1969). With *Vitis*, *Citrus*, *Prunus* and *Olea* the possibility for induction of correctly timed fruit loosening for harvest with vibrating machines is being investigated (e.g. Weaver and Pool 1968). With *Hevea* latex yield was increased by 20-25 % with chlorflurenol (Abraham et al. 1968).

With certain field crops it appears not impossible now to control vegetative growth so as to improve yields e.g. in *Vicia faba* (Schneider et al. 1967). Preliminary results indicate some dwarfing of *Glycine max* without damage to flower and fruit set, thus allowing more plants to be grown per acre. In the greenhouse *Solanum tuberosum* was induced to form more stolons and tubers per plant, and tuber size was limited (Humphries and Pethiyagoda 1969). With *Fragaria vesca* good runner control was achieved without unwanted side-effects.

With ornamentals some interest with morphactins is directed towards an intensification of vegetative propagation by layers and cuttings (induction of increased branching in stock plants) (Schneider et al. 1967), e.g. with *Chrysanthemum*.

Interesting effects of morphactins on regeneration processes have been recorded (Pieniazek et al. 1968, Schneider 1967), which may become of some importance in rooting of woody cuttings and in grafting e.g. of *Vitis vinifera* (Alleweldt and Bourquin 1967, Julliard 1966).

Finally, another point of interest: morphactins limit the growth of shoots and the leaf area for transpiration (Schneider et al. 1967, 1970). They are therefore included in a programme for chemical induction of improved drought tolerance for growing certain crops under arid conditions (Sankhla and Sankhla 1969, 1970).

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THE EFFECTS OF THE USE OF HERBICIDES IN CEREALS ON THE FEEDING ECOLOGY OF PARTRIDGES

G. R. Potts
The Partridge Survival Project, Game Conservancy,
North Farm, Washington, West Sussex.

Summary The decline of the Grey Partridge can be explained in terms of decreased chick survival which can, in turn, be linked to changes in the abundance of their arthropod food in cereal crops.

Under favourable conditions herbicides can temporarily reduce the number of arthropods in the cereal crop to about 30% of that in untreated crops. Further reductions are associated with the decline of undersowing. With cleaner crops and fewer arthropods, aphid outbreaks become increasingly probable, and in 1970 they soon compensated for the reduction of other insects. However, if the weather in April and May is cold the aphids cannot increase in time to be of use to the partridges. Since about 1955 the chick survival rate has therefore been depressed by cold spring weather and this has led to the unprecedented decline of the species.

INTRODUCTION

The Partridge Survival Project was set up in October 1968 in order to isolate and then rank the causes of the recent decline of the Grey Partridge (Perdix perdix). The project is based in West Sussex and mainly uses a large area of chalk Downland given over to cereals and about 10 miles to the west of Brighton.

Investigation of the records in game books show that the decline is unprecedented (Potts 1969) and due to an increase in the chick mortality rate in cereal crops (Blank et al 1967, Potts 1970(a)). Although it has been known for many years that the chicks must feed on arthropods for the first 15 days or so (Ford et al 1938) it has only recently been shown that this diet is essential, in the laboratory; Cross and Southwood (1970) and in the field; Potts (1970(a) and unpublished).

In each of 6 field experiments Southwood & Cross (1969) demonstrated that the treatment of cereals with a herbicide reduces the number of arthropods (excepting soil fauna) to about one half and the biomass to about one third of their values in a 'weedy' field. These authors calculated that the treatment of cereals with herbicides would lead to a three or four fold increase in foraging effort on the part of the partridge chick and conclude that this has led to the decline of the chick survival rate. Subsequently as a result of field work during 1969 and 1970, a somewhat modified version of this theory was found to explain the recent decline in chick survival (Potts 1970(a) and unpublished). Now that the more toxic herbicides (such as the di-nitro cresols) are rarely used, no other adverse effects of herbicides on survival are suspected although the weed seed composition of the diet of the adult Partridges has greatly changed (Potts 1970(b)).

The present paper describes the first stages of an investigation designed to account for the wide spatial and temporal variations in the arthropod density of cereals. Herbicides are considered as important ecological parameters in the cereal ecosystem and their effects on the invertebrate fauna are thought to be the most important of their ecological side effects.

METHODS

In 1970 studies of the effects of the normal use of herbicides on the distribution and abundance of arthropods was carried out over about 5000 ac of cereals. A portable petrol driven vacuum insect net was used to give quantitative samples of arthropods in 183 fields. Most of the fields were sampled on 2-4 June and again on 16-19 June. In addition 15 fields of spring sown barley were studied in late May and early July, and also at 10 day intervals with a conventional sweep net. Each of the samples were formed of 5 randomly placed sub-samples of 1ft^2, and generally contained a mixture of soil, plant debris and arthropods. The samples were deep frozen soon after collection and stored until sorting which took about 2 hours per sample. All animals were counted and identified as far as possible, although, as a rule only those which were frequently eaten by partridges were identified to species. The main purpose of the investigations is to map the geographical distribution of the prey insects at varying densities and to compare this data with a similar map of chick survival.

It was impracticable to assess weed density in the precise area covered by the vacuum net during the sampling, so that certain weed dwelling coleoptera were used as indicators of the presence of dicotyledonous weeds. These were the seed eating Curculionids, *Meligethes* spp, the Halticinae (except *Crepidodera* *spp*), *Cassida* *spp* and *Gastrophysa* *polygoni*. The total individuals belonging to these species and groups was called the 'index of weed abundance'. This method overcomes many of the difficulties of allowing for patchiness due to inefficient herbicide application of one kind and another.

RESULTS

By mid June 1970 half of all the arthropods in the cereals were aphids and by the end of that month there were concentrations of up to 6000m^2. These were almost all of two species, *Metapolophium* *dirhodum* on the leaves and *Sitobion* (*Macrosiphum*) *avenae* on the ears. In early June there were more arthropods in weedy areas. If we adopt the index method it is apparent that the arthropod density in these places is three times that in weed-free areas - see Table 1.

Table 1

Relation of the density of arthropods to the abundance of dicotyledonous weeds in cereals, Sussex 2-4 June 1970

Index of weed abundance (From indicator coleoptera)	Number of fields sampled	Number of arthropods m^2 (geometric means and 95% confidence band)
0	49	97.4(70.4-138.4)
1 + 2	60	222.8(217.8-235.0)
2	19	312.4(303.0-332.0)
Total and grand means	128	188.1

During field work in 1969 aphids did not appear to be numerous in weedy areas. Subsequent analyses, this time of the 1970 data, show that there is a significant tendency ($P<0.01$) for aphid outbreaks to occur in fields with few arthropods at the time of the start of the aphid 'build up' - see Table 2.

Table 2

Relation of the probability of an outbreak of cereal aphids to the density of arthropods in the period 2-4 June 1970

Arthropods m^2	Number of fields examined	Probability of increase of apterous aphids per 14 days		
		>25-fold	>50-fold	>100-fold
0-99	24	0.46	0.25	0.13
100-199	18	0.50	0.33	0.11
200-399	30	0.40	0.13	0.00
400-599	20	0.40	0.00	0.00
600-1200	8	0.12	0.00	0.00
Total and means	100	0.41	0.17	0.05

DISCUSSION

Aphids

It is not clear why the simpler parts of the cereal ecosystem should be susceptible to aphid outbreaks but it is likely that the total number of arthropods is a good measure of the potential predation pressure. Although very little is known of the preferred food of most of the arthropods it is known that many of them are general predators.

There is little information on long term changes in cereal aphid density but data concerning trapped migrants from 1951-1969 at Rothamsted suggest a five fold increase starting in the mid 1950's (Heathcote 1970). In Canada a similar increase appears to have taken place (Adams & Drew 1965). Thus it appears that the simplification of the cereal ecosystem with the use of herbicides has been associated with an increase of cereal aphids - certainly many field workers and farmers consider cereal aphids to be on the increase.

Effects on the Partridge

Aphids are a preferred food of the partridge chick - so how can herbicides adversely affect their survival? The reason is that aphids cannot often compensate for the loss of weed dwelling insects and for the loss of insects which are dependent on undersowing. Cold springs delay the aphids (e.g. Heathcote 1966) but not the partridges so that, as in 1969, (Potts 1970(a)) the chicks may hatch about ten days before the aphids are numerous enough to form an adequate diet. Thus since about 1955 the chick survival rate has been depressed by cold weather - especially in May and this has led to the unprecedented decline. The species is now 5.6 times more sensitive to cold spring weather, as compared to the period 1868-1955.

CONCLUSION

The cereal ecosystem

Any change in cereal husbandry will trigger a vast series of chain reactions by no means all inimical to wildlife. For example if we remove the weeds we may increase the aphids, this will make the Grey Partridge more vulnerable to the weather - but favour the Red-legged Partridge which hatches later in the season. It will increase the aphid predators thus in turn increasing the food supply of aerial-feeders such as the Swifts which are often to be seen over aphid concentrations, apparently feeding on Syrphids. The ecological stability of the cereal crop is related to its complexity. A great deal of ecological strategy may be needed if we are to approach monoculture - in the strict sense - and still maintain increasing yields.

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COMPARISON OF THE PERSISTENCE AND THE VERTICAL MOVEMENT OF THE SOIL-APPLIED HERBICIDES SIMAZINE AND BROMACIL

V. Stecko
Department of Plant Husbandry,
Agricultural College of Sweden, S-750 07 Uppsala 7, Sweden

Summary Field experiments showed that the behaviour of simazine and bromacil in clay and sandy soils was different. In sandy soil bromacil had a longer persistence than in clay soil while the situation for simazine was the opposite. The phytotoxicity of simazine ceased first in the deeper soil layer, bromacil, on the other hand, disappeared first from the upper soil layer.

INTRODUCTION

Simazine and bromacil are used for total weed control on non-agricultural land. These two soil-applied herbicides have a long persistence in the soil. Reports on the persistence, however, vary due to the circumstances and the places where the experiments were carried out. It appears, however, that bromacil is more persistent than simazine (Meeklah 1964, Lange *et al*. 1968). Simazine is concentrated in the upper soil layer, while bromacil has a greater mobility in the soil profile (Burschel 1961, Burnside *et al*. 1963, O'Neill 1963, Dowler *et al*. 1968).

METHOD AND MATERIALS

At the Department of Plant Husbandry an experiment was started with the purpose of studying and comparing the persistence and the vertical movement of simazine and bromacil in two different soil types, namely, sandy soil and clay. The pH of the sandy soil was 6.7 and of the clay 8.3. The organic matter content was 2.3 per cent in sandy soil and 3.2 per cent in clay.

The experiment was started in the spring of 1966 when 3, 6 and 12 kg/ha a.i. of both simazine and bromacil were applied to the soil surface. The herbicides were not incorporated in the soil. Soil samples were taken from six different layers, corresponding to the depths of 0-4 cm, 4-8 cm, 12-16 cm, 16-20 cm, and 20-24 cm respectively. The residual toxicity was determined by bioassay with white mustard and oats. The seedlings were grown in plastic pots of 1 l. volume at a temperature of 16-20°C. After one month numbers, weights and the phytotoxicity symptoms of the seedlings were determined. The soil samples were collected on seven occasions after treatment according to Table 1.

Table 1

Time and precipitation between treatment and collections of samples

Samples	Time (days) between treatment and sampling	Precipitation (mm) between treatment and sampling
1	120	187
2	368	575
3	425	619
4	496	825
5	706	1099
6	824	1328
7	1095	1666

RESULTS AND DISCUSSION

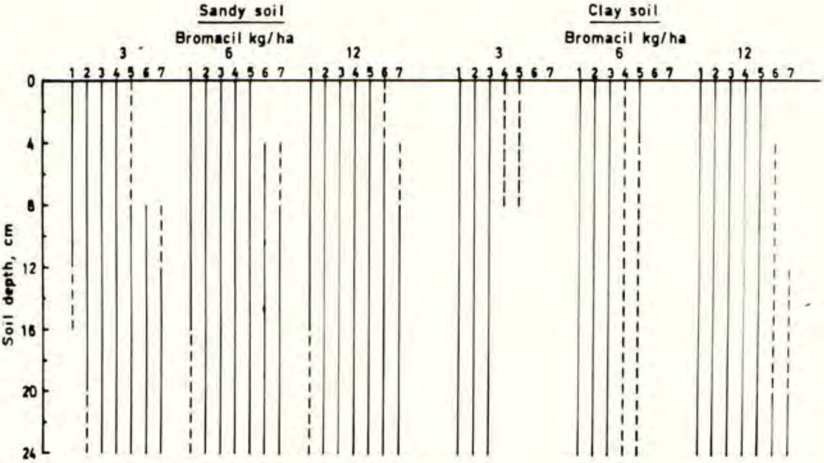
Data from the experiments with simazine and bromacil are presented in Figures 1 and 2 respectively. The figures show that the vertical movement was more rapid for bromacil, which, already 120 days after the treatment, had moved downwards at least 24 cm, while the deepest occurrence of simazine was generally observed at the second sampling, one year after treatment. Simazine was often found deeper in clay soil than in sandy soil. The probable reason for this is that during the summers the clay was severely dried out causing large cracks to form in the soil in which the herbicides were transported down together with the earth crust. The larger part of simazine remained in the top 12 cm profile of the soil while bromacil penetrated the entire 24 cm depth. With higher herbicide concentrations the downward movement of simazine increased but this movement in the case of bromacil was not influenced.

Figure 1

The vertical movement and persistence of simazine

Figure 2

The vertical movement and persistence of bromacil



The numbers 1-7 give the time for collecting of samples according to Table 1.

———— The depth where bromacil caused more than 50 per cent mortality or more than 50 per cent plant weight reduction.

- - - - - - The depth where bromacil caused less than 50 per cent mortality or less than 50 per cent plant weight reduction.

It is difficult to explain why simazine had a more prolonged residual effect in clay soil than in sandy soil, while bromacil disappeared more rapidly from the clay soil than from the sandy soil. One interpretation can be the differences in the micro-organism population in the two soil types. It is known that simazine is decomposed both by bacteria and fungi while bromacil is not affected by bacteria but the fungi (Hilton et al. 1964, Kaufman et al. 1965). Another explanation can be that during the summer the microbial activity was inhibited in the clay soil due to drought and the decomposition or the disappearance of simazine is probably more dependent on the biological processes than bromacil.

The phytotoxic effect of simazine decreased first in the deepest part of the soil profile and persisted longest in the top soil layer. Bromacil, however, with the exception of two cases, disappeared first in the upper soil layer.

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BEHAVIOUR OF UREA HERBICIDES IN SOIL WITH SPECIAL REFERENCE TO ENVIRONMENTAL CONTAMINATION PROBLEMS

H. Geissbuhler and J. A. Guth
CIBA Agrochemical Division, Basle, Switzerland

Summary Following guidelines for studying the impact of pesticides in the environment issued by the U.S. Department of Agriculture, this paper tries to evaluate the potential hazards presented by urea herbicides in the environment. Results of field dissipation studies, adsorption and leaching measurements and of a ground water contamination experiment are reported. In addition, the various mechanisms of degradation of urea herbicides are discussed. All the results presented indicate that urea herbicides do not represent a significant hazard with regard to contamination of the environment.

INTRODUCTION

The persistence in the environment of certain types of pesticides, such as the chlorinated hydrocarbons, have made the public aware of the possible hazards presented by these substances to flora and fauna, including humans.

This paper attempts to define and evaluate some of the potential hazards presented by the substituted ureas, a group of compounds which comprises an increasing variety of soil-applied herbicides. The persistence of urea herbicides depends on their behaviour in soil and aqueous systems and is affected by a number of physical, chemical and biochemical/biological factors which have been described in several recent reviews (Hartley, 1964; Sheets, 1964; Upchurch, 1966; Furmidge & Osgerby, 1967; Geissbuhler, 1969).

PRESENT REQUIREMENTS

To evaluate the potential environmental hazards presented by a particular group of herbicides, the pertinent set of laboratory and field experiments has to be clearly defined. Although a number of government bodies are in the process of defining such requirements, no definite guidelines exist at this time at the international level. The only written guide available at present appears to be that of the United States Department of Agriculture, issued on June 23rd, 1970, which is summarized as follows:

1. Rate of dissipation in soil
2. Mechanism of degradation
    (a) Photodecomposition
    (b) Microbial degradation
    (c) Degradation in water
3. Leaching behaviour
4. Residues in run-off water.
5. Binding of pesticides in soil
6. Residues in fish, rabbits and birds.

Anticipating such requirements, we have subjected a number of CIBA urea herbicides to field and laboratory experiments with various soil types (Table 1). The results are summarized below, according to the sequence of questions laid down in the U.S. guidelines.

Table 1

Origin and properties of soils used for field dissipation, adsorption and leaching experiments

Origin	pH	Organic Matter %	$CaCO_3$ %	Mechanical Analysis Clay	Silt	Sand
Otterbach BS	7.1	4.7	0.9	22.7	16.3	61.0
Stein AG	5.6	3.2	0.0	20.7	13.7	65.6
Uvrier VS	7.4	1.0	8.5	3.4	5.0	91.6
Vetroz VS	6.7	5.6	15.0	22.6	19.6	57.8

DISSIPATION OF UREA HERBICIDES UNDER FIELD CONDITIONS

Although from the agronomical point of view (phytotoxicity to rotation crops) determination of the structurally unchanged herbicide by either chemical or biological methods may be adequate, the total residue of urea herbicides has to be accounted for when examining soil systems for potential contamination hazards. For this reason, dissipation under field conditions was followed by three different methods, which have been desctibed elsewhere (Guth et al., 1969; Guth et al., 1970). Typical dissipation curves for metobromuron and chlorbromuron in soil are shown in Figs. 1 and 2. They demonstrate that under typical Central Europe climatic conditions not only the parent compound but also the total residue disappeared at such a rate that no more than 20% of the original concentration was present 5 months after application.

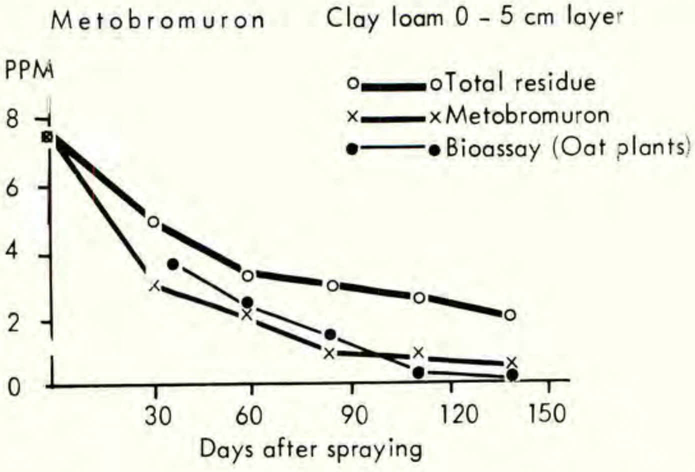
Metobromuron Clay loam 0 - 5 cm layer

Fig. 1. Rate of dissipation of metobromuron in the 0-5 cm layer of a plant-free soil (Otterbach) under field conditions. Rate of application: 4 kg a.i./ha.

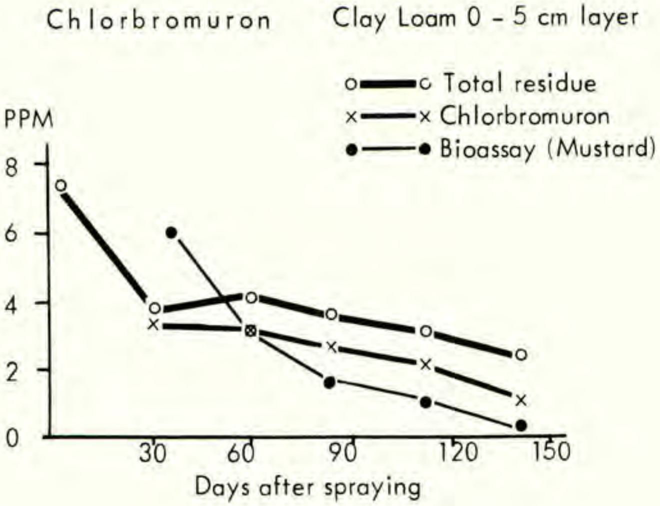

Fig. 2. Rate of dissipation of chlorbromuron in the 0-5 cm layer of a plant-free soil (Otterbach) under field conditions. Rate of application: 4 kg a.i./ha.

MECHANISM OF DEGRADATION

The present scheme of biochemical degradation of urea herbicides includes stepwise demethylation/demethoxylation, deamination-decarboxylation and binding of metabolites to certain plant and soil constituents (Geissbuhler, 1969).

Photochemical degradation mainly results in the formation of desmethyl- or desmethoxy-compounds and p-hydroxylated derivatives of the parent herbicide. (Rosen & Strusz, 1968; Rosen et al., 1969; Crosby & Li, 1969; Crosby & Tang, 1969)

The bulk of degradation and /or conjugation products formed by biochemical and photochemical processes still contains the aniline-moiety of the original phenylurea structure. Consequently, the standard residue method, which is based on colorimetric or gaschromatographic (Baunok & Geissbuhler, 1968) measurement of the aniline, after alkaline hydrolysis of the unextracted plants or soil, represents a valid procedure for examining contaminants in various materials.

In recent model experiments, carried out with unrealistically high concentrations of anilines and anilide-type herbicides applied to soil samples, the formation of small amounts of azobenzene derivatives was observed (Bartha & Pramer, 1967; Bartha, 1968; Kearney et al., 1969). This observation has precipitated numerous speculations on the formation of such azo compounds in soils treated with urea herbicides. Extended laboratory and field experiments conducted by both Du Pont (Belasco & Pease, 1969) and CIBA indicate that upon application of normal doses of urea herbicides, no detectable quantities of azobenzene derivatives accumulate in soils.

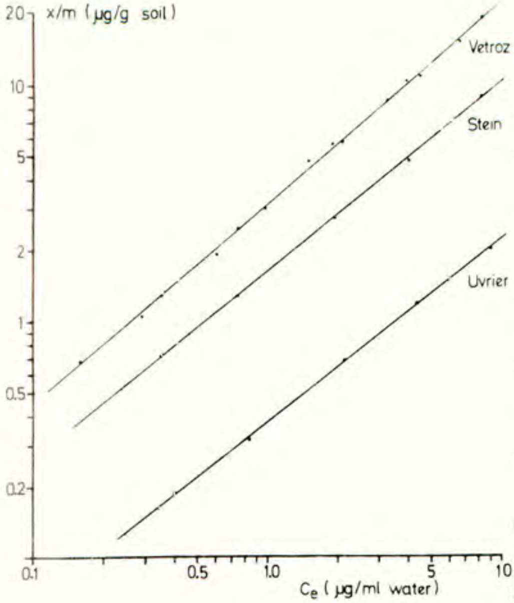

Fig. 3.

Freundlich adsorption isotherms of fluometuron obtained with three different soil types. The concentrations of herbicide fixed on the soil (x/m) have been plotted against the equilibrium concentration in soil solution (Ce) on a log x log scale.

Admitting the concentrations of the herbicide in the soil solution to be 1.0 µg/ml, the concentrations of compound fixed on the soil (µg/g) are the following:-

soil Vetroz = 3.2

soil Stein = 1.6

soil Uvrier = 0.4

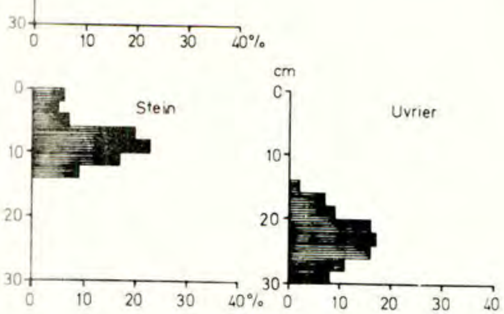

Fig. 4.

Leaching of fluometuron in three different soil types. Amount of artificial rain: 200 mm.

Rate of application: 5 kg. a.i./ha.

Formulation: 50 % wettable powder.

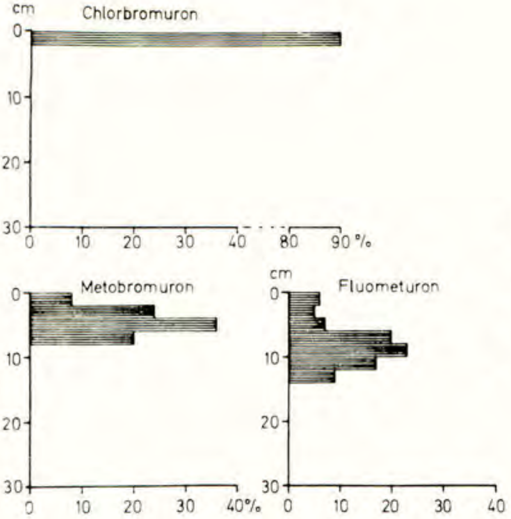

Fig. 5.

Leaching of fluometuron, metobromuron and chlorbromuron in soil Stein.

Amount of artificial rain: 200 mm.

Rate of application: 5 kg a.i./ha.

Formulation: 50% wettable powder.

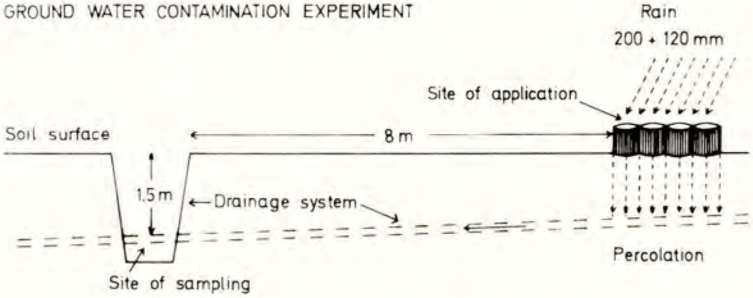

Fig. 6. Schematic diagram of a ground water contamination experiment with fluometuron.

Rate of application: 20 kg a.i./ha.

Amount rainfall: 320 mm.

Formulation: 50% wettable powder

Time of sampling: 0, 1, 3, 7, 14 and 32 days after application; samples were taken at 8.00, 12.00 and 16.00 hours each day.

ADSORPTION AND LEACHING

Possible contamination of ground and run-off water by urea herbicides depends on the adsorption and leaching behaviour of these compounds in soils. Freundlich adsorption isotherms obtained, for example, with fluometuron in standardized soil samples indicated that herbicide adsorption is suffuciently strong to prevent rapid movement through the soil profile (Fig. 3.). This indication was confirmed by actual leaching experiments in which 200 mm of artificial rain was applied to 30-cm soil columns (Figs. 4 and 5.). With this amount of rain, which corresponds to the average quantity received during the growing season, none of the compounds examined moved below the 30-cm soil level.

CONTAMINATION OF GROUND AND RUN-OFF WATER

To further verify potential contamination hazards, the most easily leached urea compound, fluometuron. was subjected to an actual ground water experiment under field conditions, (Fig. 6.). All drainage water samples, which were collected at different time intervals after application, were found to be free of fluometuron residues (less than 0.05 ppm).

RESIDUES IN FISH

In preliminary experiments, gold fish were maintained for a period of 4 days in water containing various concentrations of the urea herbicide chlortoluron. Results of analyses of fish tissue indicated that some accumulation of residues occurred when compared with the herbicide concentration of the surrounding water. However, this accumulation was too small to suggest any obvious toxicological effects on fish in water containing several ppm of the herbicide.

CONCLUSIONS

Present results of a number of field dissipation, adsorption, leaching and degradation experiments carried out according to the guidelines of the U.S. Department of Agriculture do not indicate that urea herbicide residues represent a significant hazard with regard to contamination of the environment.

Acknowledgements

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PRELIMINARY STUDIES INTO THE BIOLOGY AND CULTURAL CONTROL OF POA TRIVIALIS IN CEREAL AND GRASS SEED CROPS

E. G. Budd
National Institute of Agricultural Botany, Cambridge

Summary Trials have suggested that spring barley can be used as a cleaning crop on land infested with dormant seed of Poa trivialis provided over-wintering plants are destroyed by good seed bed preparations. Under spring barley, Poa trivialis germinates but is incapable of producing seed in the year of germination.

In grass seed crops infested with Poa trivialis, delaying stubble cultivations for three months following harvest allows the seed to germinate on the surface and thus prevents the incorporation of viable seeds into the soil where a proportion become dormant. Growing spring barley between two ryegrass seed crops is also likely to reduce the infestation still further.

INTRODUCTION

This investigation is divided into three parts:-

1. An investigation into the value of using spring barley as a cleaning crop on land infested with dormant seed of Poa trivialis. Work done by Cooper and Calder (1964) and Budd (1970,a) has shown that Poa trivialis plants need exposure to winter conditions in order to produce seed the following year; spring germinating plants may therefore be incapable of producing seed in the year of germination. This being so, it should be possible to use spring barley as a cleaning crop, provided the seed bed cultivations are sufficiently thorough to destroy any over-wintering plants. Observations on a number of barley crops during 1969 and 1970 are reported.

2. An assessment of the dormancy and survival of Poa trivialis seed, following periods of burial in the ground. Milton (1936) has shown that some Poa trivialis seeds were still viable after being buried in soil for at least 5 years. Similar work has been carried out on Poa annua by Roberts (1967), on Avena fatua and A. ludoviciana by Thurston (1966) and on Alopecurus myosuroides by Wellington and Hitchings (1965), and Lewis (1961).

3. The results are given of a three year, mainly cultural experiment designed to reduce the field infestation of Poa trivialis in a grass seed crop. The technique has been suggested by Budd (1970,a). Other cultural techniques for weed control in seed crops were suggested by Hitchings (1970).

METHOD AND MATERIALS

1. In 1969 and 1970 nine farm sites were chosen, on which to observe the behaviour of Poa trivialis plants in spring barley crops. Five of the sites were in fields known to have a history of Poa trivialis infestation. On each of these, the farmer took particular care to destroy any over-wintering plants by good autumn and

spring cultivations. This ensured that all the Poa trivialis plants found in the spring barley had germinated with or after the crop. The remaining sites were sown experimentally and included four spring barley crops and one winter wheat crop, on each of which, seed of Poa trivialis was broadcast onto the clean seed bed. On all ten sites the Poa trivialis plants were recorded for growth and seed production immediately before the cereal crops were harvested.

2. To observe the survival of Poa trivialis following burial in soil, seed was enclosed in elongated terylene mesh bags buried three and six inches deep. Each bag consisted of a 0.3 mm woven mesh which prevented any loss of the enclosed seed, but allowed the free entry of small insects, soil particles, roots, air and moisture. The bags measuring 9 in. x 1½ in. were buried lengthwise, with the seed spread evenly along the bottom to ensure close contact with the soil. Some of these seed bags were buried in the spring, in ground freshly sown to spring barley, others were buried in the autumn under a timothy crop sown the previous spring. Each experiment was replicated four times and every bag contained 150 seeds of known germination. After five months burial the seed was recovered from the ground and immediately subjected to a germination test in a Copenhagen Tank.

3. The infestation of Poa trivialis in an old seed crop of S.24 perennial ryegrass, following a cultural treatment was assessed and compared with the infestation in a new crop three years later. The sequence of events was as follows: In July, 1967, from a seed crop of S.24 perennial ryegrass twenty sample areas were cut at random immediately before harvest. Each sample was examined and the number of seed heads of Poa trivialis and ryegrass compared giving an estimate of the field contamination. After harvest, the following measures were carried out to prevent the incorporation into the soil of the numerous Poa trivialis seeds present in the combined straw and lying on the ground. First, the straw was burnt in the swath to kill as much seed as possible and the stubbles were left uncultivated until October to allow the seed on the ground to germinate. Three weeks after harvest the crop regrowth was sprayed with paraquat to kill the old crop and suppress the growth of any Agropyron repens. Three to four weeks later, the dead foliage was sufficiently dry to be set on fire. A very efficient burn was achieved which killed the remainder of the old crop, Agropyron repens regrowth, Poa trivialis seedlings and some of the ungerminated seed. The scorched ground was then left until late October before ploughing. During this period any remaining viable seed would be expected to have had a further opportunity of germinating on the soil surface, moisture conditions now being adequate for germination. In the spring of 1968 a barley crop was sown on the field, particular care again being taken to ensure that no over-wintering plants of Poa trivialis survived the spring cultivations. After harvest, the stubbles were immediately cultivated in order to expose and germinate dormant seed contained in the soil and to control any Agropyron repens. In the spring of 1969 the field was again sown with S.24 perennial ryegrass under spring barley. At seed harvest in July 1970, the crop was sampled as in 1967 to determine whether the treatments described had been successful in reducing the level of Poa trivialis infestation.

RESULTS

Figure 1 shows the field infestation of Poa trivialis in 1967 and 1970.

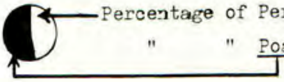
Table 1 shows the results of examining the behaviour of Poa trivialis in winter and spring cereals.

Table 2 shows the results of dormancy studies on buried seed of Poa trivialis

Figure 1

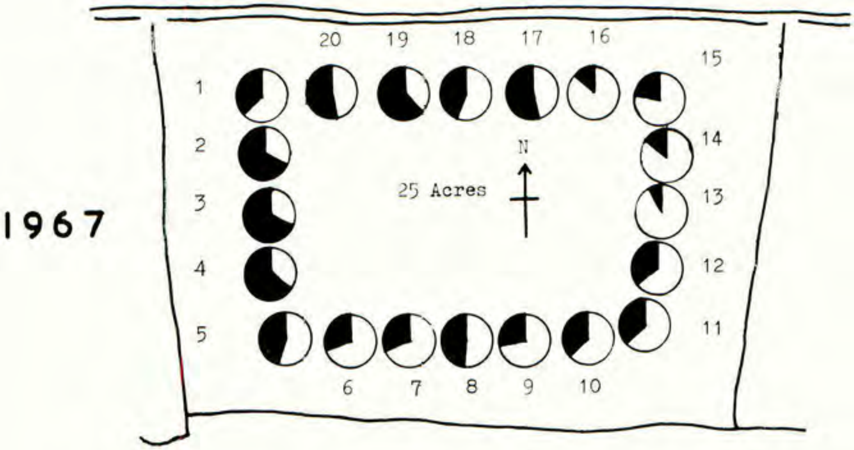
Field reduction of Poa trivialis infestation in S.24 Perennial ryegrass following Spring barley crops in 1968 and 1969

KEY Sample area of 1 yd.^{2}

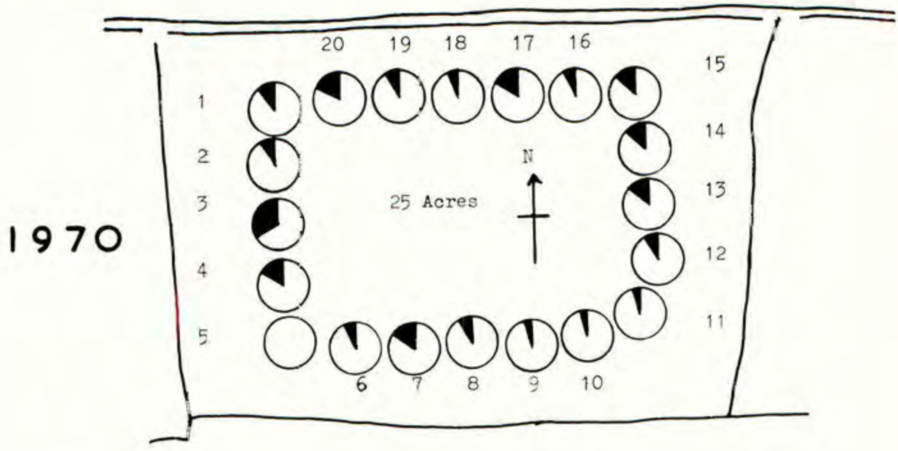


Percentage of Perennial ryegrass seed heads

" " *Poa trivialis* " "



Mean = 1,386 Perennial ryegrass + 929 *Poa trivialis* seed heads/yd.^{2}
Ratio = 100 " " : 67 " " " "



Mean = 1,73[illegible] Perennial ryegrass + 213 *Poa trivialis* seed heads/yd.^{2}
Ratio = 100 " " : 12 " " " "

Table 1

Behaviour of Poa trivialis in cereal crops

Site	Crop	Sown	No. of plants examined	No. of plants producing seed	Mean number tillers/plant
1	Spring barley	March 1969	50	0	2.7
2	" "	" "	50	0	3.4
3	" "	" "	100	0	3.0
4	" "	" "	320	1	1-3
5	" "	" "	320	0	1-3
6	Spring barley	March 1970	50	0	4.5
7	" "	" "	50	0	3.0
8	" "	" "	300	0	2.3
9	" "	" "	200	0	1.5
10	Winter wheat	Nov. 1969	100	1	6.5

Table 2

Survival of Poa trivialis seed following burial in soil under spring barley and timothy

Site	Soil type	Crop	Duration of burial	Percentage reduction in the viability of seed buried at:		
				½ in.	3 in.	6 in.
Cambridge	Clay	Spring barley	March-August '69	-	9	3
Hampshire	Loam	" "	" " "	-	36	2
Hampshire	Loam	Spring barley	March-August '70	-	9	42
Hampshire	Loam	Timothy	October-March '70	21	26	40

DISCUSSION

1. The results show that Poa trivialis plants in the ten cereal crops failed to produce seed heads during 1969 and 1970 and that the addition of new seed to that already present in the soil was prevented. The single winter wheat crop observed gave the same result as the nine spring barley crops, despite the probability of the plants being fully vernalized. Budd (1970,a) showed that single spaced plants grown from seed germinating during the period November to March are fully vernalized, and therefore, those germinating in the winter wheat should have produced seed heads. The Poa trivialis, however, did not germinate until December and failure to head could have been due to intense competition from the strong wheat crop, accentuated by the late germination of the weed. The wheat crop in this case yielded over 40 cwt/ac. It has also been observed in spring cereals, that old plants of Poa trivialis which have survived autumn cultivations and overwintered, are capable of producing seed heads because they are vernalized and more competitive. It is important, therefore, that these and all autumn germinating seedlings must be destroyed by good cultivations if spring barley is to be regarded as a cleaning crop.

2. From the burial of Poa trivialis seed for 5 months no clear pattern emerges to show whether season, soil type, depth or duration of burial influences the degree of survival. The results show, however, that at least 60% of the seed can survive 5 months burial. Roberts and Dawkins (1967) working on Poa annua and Thurston (1966)

on Avena fatua and A. ludoviciana, found exponential decreases of 21% to 26% per year in the viability of buried indigenous seed. Assuming an exponential decrease of 25% per year the viability of the initial population would still be 1% after 16 years.

3. Examination of the samples taken from the grass seed crop in 1970, when compared with those taken in 1967 showed an average reduction of 77% in the number of Poa trivialis heads and an increase of 20% in the ryegrass. The crop seed yield also increased by 14%. It is reasonable to assume, therefore, that the cultural treatment imposed on this field since harvest in 1967 reduced the infestation of Poa trivialis and may have increased the grass seed yield. However, as under this type of field experiment it was not possible to leave untreated controls, the assumption cannot be proved. If the cultural sequence described is the reason for this improvement, then the main factor responsible is the change in the farmer's practice of treating the stubbles. Prior to 1967 it was customary to break up and rotovate the stubbles of an old grass seed crop immediately after harvest in July to control Agropyron repens. Unfortunately in doing this, the viable seed of Poa trivialis on the ground became incorporated into the soil where a proportion became dormant. Figure 1 shows the presence of 929 heads of Poa trivialis per square yard in the 1967 seed crop. Since such heads can produce a mean of 1,100 seeds per head, with a viability of 95% soon after shedding (Budd unpublished), incorporation into the soil can soon lead to a large build up of dormant seed. Work done by Budd (1970,a) has shown that given suitable weather conditions Poa trivialis seed on the ground in July can all germinate by the end of August and that cultivations could then be carried out without risk of incorporating potentially dormant seed. Agropyron repens can also be suppressed by spraying the seed crop aftermath three weeks after harvest, with paraquat and then burning the dead dry foliage after another three weeks. This leaves at least another month for any viable seeds to germinate before cultivating in October. Spring barley following a grass seed crop will further reduce the viable population of Poa trivialis seed in the soil and, provided the barley stubbles are cultivated immediately after harvest, Agropyron repens can also be controlled.

In conclusion, it is hoped that the cultural sequence described will prevent the increase of Poa trivialis seed in the soil and also clean out dormant seed already present, without encouraging the ingress of other weed species such as Agropyron repens. Such treatments could complement herbicide controls as outlined by Budd (1970,b).

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