HERBICIDE STUDIES ON CARROTS AT INVERMAY

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Summary

In a study of various materials for the replacement of herbicidal oils for selective weed control in carrots, it was shown that chlorpropham applied before crop emergence could safely be used. Propazine was also satisfactory but rates above 1½ lb a.i./acre left residues lethal to oats sown 9 to 10 months after application. Carrots were tolerant to post-emergent applications of linuron. No demonstrable effect occurred on the palatability of carrots treated with various herbicides.

INTRODUCTION

HERBICIDAL OILS with a low content of phytotoxic aromatic compounds are commonly used for weed control in carrots, and certain proprietary mineral oils with an aromatic content of not less than 15% but not more than 25% are produced for this market. However, these materials are rather expensive and some growers persist with the use of power kerosene with the attendant risk of crop damage. In this report an account is given of a comparison between a refined mineral oil and power kerosene together with a study of various materials for replacement of herbicidal oils.

MATERIALS AND METHODS

One variety of carrots, Chantenay Red Core, was used throughout. All materials are quoted on a per acre basis, and were applied by a mechanical plot sprayer or an Oxford Precision sprayer. All trials were carried out within one area at Invermay, having reasonably constant soil characteristics. Mechanical analysis by the Bouyoucos method showed a physical composition as follows: 7.3% coarse sand, 27.1% fine sand, 31.0% silt, 34.6% clay: there was 7.4% stones and gravel in the original sample. This soil is classified as a clay loam: its cation exchange capacity was 25 to 30 m.e.%

There was no marked variability in weed infestation throughout the experiments. Wireweed (*Polygonum aviculare*), bindweed (*P. convolvulus*), redshank (*P. persicaria*) were always present (except in Experiment D), while fathen (*Chenopodium album*) was more sporadic, and overall was not as frequent as the polygonaceous weeds.

In these experiments the proprietary mineral oil used was "Shell W" with an aromatic content of 23 to 25%. Power kerosene is not controlled for aromatic content, but a representative sample contains 40 to 45% aromatics.

Four field experiments are reported in detail. Table 1 shows the materials applied and the crop development at the time of application.

All treatments are referred to as pounds active ingredient per acre.

TABLE 1: MATERIALS APPLIED AND CROP DEVELOPMENT AT TIME OF APPLICATION

EXPERIMENT A		EXPERIMENT B	
Herbicide (lb)	Crop Development	Herbicide (lb)	Crop Development
Chlorpropham 6	{ Seed germinated but not emerged 80% one true leaf expanded	Chloramben 4	{ Seed swollen but testa intact 1-2 true leaves
Chlorpropham 8		Diquat 1	
Kerosene 30 gal		Propazine 4	
Kerosene 60 gal		Chlorpropham 6	
"Shell W" 30 gal	Ditto	Hand-weeded	Untreated control
"Shell W" 60 gal			
Hand-weeded			

EXPERIMENT C		EXPERIMENT D	
Herbicide (lb)	Crop Development	Herbicide (lb)	Crop Development
Propazine 1½	{ Seed germinated radicle ½ in. long but not emerged	Linuron ½	{ 2-3 true leaves
Propazine 2		Linuron 1	
Propazine 2½		Linuron 2	
Propazine 3		Linuron 1+	
Chlorpropham 4		wetter	
Chlorpropham 6	1-2 true leaves	Hand-weeded	Both pre- and post-emergence.
Hand-weeded			

RESULTS

WEED CONTROL AND YIELDS (TONS/ACRE)

Experiment A

Satisfactory control of fathen, wireweed, bindweed and redshank was given by chlorpropham at 6 and 8 lb pre-emergence. This compared favourably with that shown by post-emergent treatments of power kerosene and "Shell W". Good weed control was obtained by "Shell W" at 60 gal and power kerosene at 30 gal, but with power kerosene at 60 gal crop damage became severe. "Shell W" at 30 gal was the least efficient of all treatments. However, weed control was fair and in commercial practice a follow-up with mechanical hoeing would probably have given excellent results.

Hand-weeded control yielded significantly better than all other treatments, while the two best herbicides were chlorpropham 8 lb and "Shell W" 60 gal, both yielding 2 tons per acre less than control. All other treatments were significantly lower with a further reduction in yield of 2 tons per acre (see Table 2).

Experiment B

Weed control by chloramben 4 lb pre-emergence was good but rather variable, while propazine 4 lb and chlorpropham 6 lb were excellent. Diquat applied pre-emergence was unsatisfactory because the majority of weeds had not germinated at the time of spraying. It was noted that sow thistle (*Sonchus oleraceus*) often persisted in chlorpropham plots but not where propazine was applied.

There was no difference in yields from chlorpropham, propazine or hand-weeded control. Chloramben and diquat gave lower yields

TABLE 2: CARROT YIELDS (TONS/ACRE)

EXPERIMENT A		EXPERIMENT B	
Chlorpropham 6 lb.....	16.8 cdC	Chloramben 4 lb.....	37.7 aAB
Chlorpropham 8 lb.....	18.6 bB	Diquat 1 lb	34.1abAB
Kerosene 30 gal	16.7 cdC	Propazine 4 lb	44.6 aA
Kerosene 60 gal	16.9 cC	Chlorpropham 6 lb.....	42.0 aA
"Shell W" 30 gal	16.3 dC	Hand-weeded	
"Shell W" 60 gal	18.5 bB	control	44.6 aA
Hand-weeded		Control	26.9 bB
control	20.5 aA	C.V.	17.1%
C.V.	7.9%		

EXPERIMENT C		EXPERIMENT D	
Propazine 1½ lb	55.7 abA	Linuron ½ lb	44.2 aA
Propazine 2 lb	55.6 abA	Linuron 1 lb	40.1 abA
Propazine 2½ lb	53.6 bA	Linuron 2 lb	37.6 bA
Propazine 3 lb	58.2 aA	Linuron 1 lb +	
Chlorpropham 4 lb.....	58.4 aA	wetter	40.0 abA
Chlorpropham 6 lb.....	58.2 aA	Hand-weeded	
Hand-weeded		control	41.2 abA
control	58.0 abA	C.V.	9.6%
C.V.	4.9%		

and were not significantly different from unweeded controls at the 1% level.

Experiment C

Initially only propazine at 1½ lb was poorer than the standard chlorpropham treatments, but later wireweed recovered sufficiently on propazine 1½ and 2 lb plots for their weed control ratings to drop to poor and fair, respectively, while 2½ and 3 lb were fair to good, with both chlorpropham treatments good to very good.

Crop yields were unaffected by treatment. Propazine at 2½ lb depressed yields (a possibly anomalous result) but no treatment differed significantly from hand-weeded control.

Experiment D

Few weeds were present in this trial and it was maintained weed-free by hand throughout the season to establish the crop tolerance to linuron. Yield data show that there is an inverse response to increase in dosage, and at 2 lb/acre yields were significantly lower than at ½ lb, although none were significantly less than control. The addition of a non-ionic wetting agent to the 1 lb rate did not affect crop tolerance in any way.

Further Trials

Other field experiments were carried out over a number of years. Of those not reported above, one studied the effect of chlorpropham at 4, 6 and 8 lb applied pre-emergence with a further 4, 6, and 4 lb, respectively, added post-emergence. Chlorpropham 6 and 8 lb pre-emergence gave almost complete control of weeds, while the

post-emergence applications had little effect on any survivors. These high total quantities (12 lb) of chlorpropham did not adversely affect yields. In another trial, chlorpropham 4 lb, CDAA 4 lb, chlorpropham 1 lb + CDEC 2 lb, and EPTC 4 lb were rotary-hoed into the seedbed before sowing, but none was as efficient as chlorpropham 6 lb applied after drilling. In addition, chloramben 4 lb after sowing was only fair, failing wherever weed infestation was intense. There were no significant yield differences. Experiment A was repeated and, although carrot yields were not taken, weed control effects and crop vigour were essentially the same as in Experiment A.

SOIL RESIDUES

A qualitative bio-assay to detect propazine residues in soil from the trial sites was made, using oats as an indicator. Nine months after propazine application, soil samples to a depth of 0 to 3 in. were taken from propazine and control plots (Experiment B). Samples were bulked and each split into 10 pots which were then each planted with 10 oat seeds, and held in an unheated glasshouse.

Oat germination in propazine-treated soil was slower than in control soil, but ultimately was the same. The delay in germination may possibly have been because propazine-treated soil lacked crumb structure and was difficult to get into a friable state ready for sowing. It was noted that propazine pots were relatively weed-free compared with controls. Thirty days after sowing, oats in propazine pots appeared pale and growth began to slow down: 10 days later they had collapsed, all but 2 pots being severely affected. Symptoms were typical of triazine damage.

Similarly, in Experiment C residues of propazine were sufficient to cause death of oat plants (assayed 10 months after application). In this trial samples were tested on a plot by plot basis.

Again it was noted that propazine-treated soil lacked crumb structure, but no effect was noted either in the time or total numbers of seeds germinating.

There was a good correlation between weed infestation in pots and on the original field trial plots—*i.e.*, hand-weeded controls were always weed-free, the weediest treatment was chlorpropham 4 lb, while the 6 lb rate carried some sow thistle, redshank and to a lesser extent fathen. Propazine treated pots were weedier at the 1½ lb rate than at 3 lb: weeds which had germinated in the higher rates (2½ and 3 lb) wilted before or at about the time that oat indicator plants collapsed. The mean percentage of oat plants affected by severe triazine symptoms was:

Propazine 1½ lb	.....	.....	.....	.....	.....	.....	5%
Propazine 2 lb	.....	.....	.....	.....	.....	.....	40%
Propazine 2½ lb	.....	.....	.....	.....	.....	.....	60%
Propazine 3 lb	.....	.....	.....	.....	.....	.....	95%

EFFECT ON PALATABILITY

Carrot samples from several experiments including A and B were submitted to tasting panels either from the University of Otago Home Science School or Invermay Research Station. Various designs capable of statistical analysis were employed but in no cases were significant differences demonstrated.

Where heavy total rates of chlorpropham (*i.e.*, 6 lb pre-em. + 6 lb post-em. or 8 lb pre-em. + 4 lb post-em.) were applied, it was found that a flavour difference could be detected by a proportion of the population, but the analysis could not indicate any quantitative estimate of this proportion.

DISCUSSION

Results of these experiments indicate that a refined mineral oil ("Shell W"), although not as effective in controlling weeds as power kerosene, gave similar or better yields of carrots. However, rates of kerosene as high as 60 gal/acre may cause crop damage: furthermore, kerosene may vary in its percentage of aromatic compounds and, where these are high, phytotoxicity is increased. It may thus be wise to avoid its use and spray early with a refined mineral oil. It was shown that rates of chlorpropham at 6 to 8 lb can give excellent weed control with carrot yields similar to the herbicidal oils quoted above, and considerable increases in yield over unweeded controls.

Carrot tolerance to chlorpropham was excellent and even totals of 12 lb did not reduce yields. No place could be demonstrated for post-emergence application of chlorpropham, and little advantage was found in economizing on dose rate by cultivating chlorpropham (4 lb) into the seedbed, as weed control was inferior to 6 lb post-emergence while yields were similar.

Two other carbamates (EPTC, and CDEC) and an amide (CDAA) were inferior in control value to chlorpropham, and chloramben, although distinctly promising, was somewhat variable. Only propazine appeared to be comparable with chlorpropham. Both have slight weed control deficiencies in that chlorpropham permits strong establishment of sow thistle in particular and probably all Compositae in general, while propazine tends to allow redshank to become established after an initial period of control. At dosage rates low enough to avoid problems with soil residues, propazine at 1½ lb also permits sufficient wireweed recovery to render it considerably poorer than chlorpropham at 4 to 6 lb.

The use of propazine on light alluvial soils low in clay and humus should be avoided unless previous trial work has established safe dosage rates (G. W. Mason, pers. comm.). There is a high correlation between cation exchange capacity and the amount of clay colloids and/or humus in a soil. It is known that chlorpropham is strongly adsorbed by soils, especially those high in organic matter (Columbia S.C.C., 1958). In the investigations at this station 6 lb chlorpropham was found to be necessary to achieve satisfactory weed control (less than 1 or 2% weed cover) on a soil with a cation exchange capacity of 25 to 30 m.e. %. Where exchange capacity is high, it is necessary to increase the rate of application, and thus growers are advised to determine the exchange capacity of their particular soil and modify the rate of chlorpropham accordingly.

It should be noted that, in cases of pre-emergence application of chlorpropham at Invermay, spraying was carried out close to crop emergence rather than close to drilling of the crop. Alban (1952), and Timmons and Lee (1954) working with onions, reported that application close to emergence was more effective than application soon after drilling.

Linuron, a recently released material for post-emergent application, is said to be quite adequate for weed suppression in carrots (Stephens, 1962), but rates of 1 to 2 lb may be necessary. On the Invermay soil type, there was a tendency for 2 lb to reduce yields in a weed-free tolerance trial; thus it may be wise to avoid rates above 1 lb until more experience has been gained.

CONCLUSIONS

Chlorpropham applied before crop emergence can safely replace post-emergent applications of certain herbicidal oils. Carrots are

tolerant to linuron, and where post-emergent treatment is favoured linuron may prove to be a suitable material.

Only rates of propazine above 1½ lb compared favourably with chlorpropham, but unfortunately such rates may cause problems with soil residues lethal to certain crops.

No demonstrable effect occurred on palatability of carrots treated with various herbicides: excessive rates (up to 12 lb) of chlorpropham were necessary before any influence on flavour could be detected.

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