HERBICIDES FOR HORTICULTURAL BEET CROPS

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Summary

Experiments carried out in 1968 confirmed the tolerance of red and silver beets to pyrazon, lenacil and phenmedipham. Combination treatments of the last two chemicals were particularly promising. Propachlor and bensulide did not show adequate crop safety and cycloate was not sufficiently active. The results demonstrated the importance of warm, moist seedbeds for the satisfactory performance of residual chemicals and thus the advantage which is held by a suitable foliage-applied chemical such as phenmedipham.

INTRODUCTION

THERE is increasing interest in beetroot grown for processing, bottled or canned whole. Work on the development of herbicides in this crop has recently been reported from Scotland (Lawson, 1968).

The total area of red and silver beet in New Zealand was about 500 acres in 1968-9 and herbicide use is at present confined mainly to processing crops in Hawke's Bay. The need for closer plant spacing to meet the processors' requirement of small-sized beet provides the main stimulus for the wider adoption of chemical weed control rather than hoeing methods.

Much is already known about the main soil-applied herbicides which can be used in beet crops. This is due largely to the importance of the sugar beet industry in Europe and the rapid acceptance of herbicide use as an integral part of the process of crop mechanization.

Pyrazon was first tested in 1961 and work during the following three years in Germany, France and the U.K. did much to establish the factors which will contribute to its successful use. Pyrazon is reliable only if soil and weather conditions are moist and mild. Generally favourable experience has been reported from Ireland (Mitchell, 1966). The recommendation of 3 lb/acre for medium loam soils must be reduced on light and sandy soils to avoid the risk of damage to beet. New Zealand experience agrees with European results and in 1966, at the last conference at which a beet session was held, it was felt that pyrazon would not provide a panacea considering the local vagaries of the country's climate.

Lenacil was also extensively tested on sugar beet in Europe during the period 1962-5 and then marketed in 1966. It has not received much attention in New Zealand as local interest in sugar beet was waning by the time lenacil was being seriously developed. It is less dependent on soil humus content than pyrazon. Foliar absorption is insignificant and, as with pyrazon, lenacil is reliant on soil moisture after spraying.

The importance of sufficiently moist seedbeds is demonstrated by differences in results obtained with pyrazon and lenacil reported here. Probably two newer materials, cycloate and bensulide were also affected by dry conditions. In the trials which included propachlor, good conditions for chemical activity were obtained.

Six replicates

Three replicates

Y534
Levin
16/9/68
—
18/9/68
18/10/68
7/1/69

Doses, lb/acre a.i.

Y535
Levin
20-21/11/68
20/11/68
21/11/68
24/12/68
—

3, 4¹/₂, 6

6, 9, 12

1
3
1 + 3

5
1
3
1 + 3

1, 2

The discovery of the foliage-applied chemical phenmedipham announced by Arndt and his colleagues in 1967 and recently reported in more detail (Arndt and Kotter, 1968) has already had considerable impact on beet cropping. These authors report outstanding tolerance of all beet varieties tested and list easily controlled important weeds such as *Stellaria media*, *Galinsoga parviflora* and species of *Chenopodium*, *Galeopsis* and *Cruciferae*. *Polygonum* species are not so easily controlled and redroot (*Amaranthus retroflexus*) was shown to be resistant and, in common with the beets, able to inactivate phenmedipham.

In preliminary tests with phenmedipham at Levin in 1967, two formulations, coded Sch. 4072 and Sch. 4075, were compared. It was found that Sch. 4072 at 2 lb/acre gave results similar to Sch. 4075 at half this dose and there was a suggestion that Sch. 4075 was slightly less selective. This has been confirmed by other workers (Edwards, 1968). When it became known that Sch. 4075 was to be developed commercially this formulation was used in the subsequent experiments reported in this paper.

EXPERIMENTAL METHODS

Four experiments were carried out. Two of them were screening tests in which both red and silver beets were included and two were detailed trials on red beet, one situated at Levin and one in Hawke's Bay. Seedbeds were prepared and fertilizers applied at recommended rates for the beet crop. Decorked seed, graded to 9/64th inch, of the varieties Detroit Red and Fordhook Green, was drilled using a Stanhay Precision Seeder.

Spraying was carried out using a modified Oxford sprayer (Cox, 1968). Commercially formulated herbicides were applied at 25 to 30 gal/acre. In combination treatments, satisfactory spray mixtures were obtained with pyrazon (80% wp) plus lenacil (80% wp), lenacil plus phenmedipham (16.7% ec) but not pyrazon plus phenmedipham. After experiencing precipitation trouble with the latter mixture, the chemicals were thereafter sprayed separately. Propachlor was applied both as a spray (65% wp) and as granules (20%). Granules were applied with a small hand-operated blower, covering the ground twice to ensure uniform distribution.

In Experiments Y534 and H1 pre-emergence treatments were applied under conditions of seedbed moisture and warmth conducive to good herbicidal activity. A hold-up in the supply of chemicals led to a delay in laying down Experiment Y535 until a rather dry time. This resulted in irregular beet emergence probably aggravated in the case of cycloate (75% ec) treatments by the need to mix the chemical into the soil. Incorporation was carried out with a rotary hoe working at 2 in. depth and this resulted in further deterioration of the tilth. Pre-emergence applications of bensulide (48% ec), lenacil and pyrazon were made to a dry soil surface. Post-emergence treatments were sprayed at several stages of crop development. In Experiment Y535, spraying was carried out at the beet 4- to 6-true-leaf stage under conditions of high humidity and quite high air temperatures (70 to 73° F). In the other experiments, at both cotyledon and first-true-leaf stage applications, the weather was fine and temperatures more moderate (50 to 54° F). In all cases, the crops were making quick growth. In Experiment Y534, the beets were singled after the first assessment to 4½ in. spacing in the row. This resulted in a final plant population of 74,000 per acre. The unthinned final population of Experiment H1 averaged 69,000 plants per acre.

Table 1 summarizes operational details of the experiments and their treatments.

RESULTS

EXPERIMENT Y535

Judging by previous experience of the crop, beet vigour in this experiment was rather poor (see Fig. 1). Environmental conditions which may account for this have been discussed. In addition, bensulide treatments clearly depressed the crop and even at the lowest dose, 6 lb/acre, caused severe damage. None of the other treatments can be said to have had any consistent effect on crop vigour nor was there any difference in the reaction of red and silver beets to any treatment. One treatment, lenacil 1 lb/acre plus pyrazon 3 lb/acre, gave excellent control of the main weed species, willow weed (*Polygonum persicaria*), fathen (*Chenopodium album*) and black nightshade (*Solanum nigrum*) and the mixtures of lenacil 1 lb/acre with phenmedipham at both 1 and 1½ lb/acre gave quite good general weed control; where it occasionally occurred it was noted that redroot survived this treatment. Soil applications of cycloate, bensulide, also lenacil and pyrazon applied singly, gave unsatisfactory weed control, although it is worth noting that fathen was particularly susceptible to bensulide.

FIG. 1: Experiment Y535. Summary of assessments of beet and weed vigour (0 = maximum effect, absence of almost all plants. 10 = full plant vigour).

EXPERIMENT Y536

Under moist, warm seedbed conditions, the early growth of both crop and weed seedlings was rapid and cotyledon stage applications were separated by only three days from applications made when the young beet plants had attained their first true leaf. During the two-week period between the first spraying date and the first assessment of results, natural weed density doubled from an average of 63 to 126 plants per square foot. These consisted mainly of the same species as occurred in Experiment Y535 and also twincress (*Coronopus didymus*) and toad rush (*Juncus bufonius*). With the exception of one treatment (phenmedipham 1 lb/acre applied at the beet first-leaf stage which did not adequately control willow weed) very good results were obtained at this first assessment (see Fig. 2).

- a. 14 days after cotyledon stage spray.
11 days after first true leaf stage spray. Control weeded after this assessment.
- b. 35 days approx after spray. Control weeded after this assessment.
- c. 70 days approx after spray.
- d. 84 days approx after spray. Yields of red beet roots (upper) and silver beet tops (lower) expressed as % of phenmedipham 1 + lenacil 1/2 treatment.

FIG. 2: Experiment Y536. Summary of assessments of beet and weed vigour (0 = maximum effect, absence of almost all plants. 10 = full plant vigour).

TABLE 2: EXPERIMENT No. Y534 — YIELDS OF BEET, TONS/ACRE

Treatment (Doses as lb a.i./acre)	Size Grades			Total
	< 2in.	2-3 in.	> 3 in.	
Pre-emergence				
lenacil 1	0.4 abAB	5.9 abABC	7.7 bcBC	14.0 bB
pyrazon 3	0.2 bcAB	6.2 abAB	10.7 aAB	17.1 aA
lenacil 1 + pyrazon 3	0.4 abAB	5.4 bcBC	10.3 abAB	16.1 aAB
Post-emergence				
phenmedipham 1	0.3 abcAB	5.5 bcABC	11.4 aAB	17.2 aA
phenmedipham 2	0.5 aA	6.7aA	6.7 cC	13.9 bB
pyrazon 3 + phenmedipham 1	0.4 abAB	5.7 bcABC	11.2 aAB	17.3 aA
Control	0.1 cB	4.9 cC	12.1 aA	17.1 aA
CV	48.4%	12.6%	21.6%	10.7%

As the season progressed, phenmedipham treatments became weedier as recovery occurred (from the later lower dose application) or as weeds emerging subsequent to treatment developed.

Phenmedipham gave better weed control at 2 than at 1 lb/acre at both application dates; at the earlier stage, the higher dose caused a small but consistent crop check.

In terms of full season weed control, all combinations of phenmedipham with lenacil or pyrazon were very effective with phenmedipham and pyrazon giving marginally better results owing to a more complete control of willow weed.

None of the combination treatments caused more than a slight check in growth.

Yields were assessed in comparison with the combination treatment of phenmedipham 1 lb/acre and lenacil $\frac{1}{2}$ lb/acre. Yields from single treatments of phenmedipham suffered as a result of weed competition by the end of the season and generally this affected the weights of red beet roots more than silver beet tops. Treatments of phenmedipham and pyrazon which gave best weed control resulted in yields slightly lower than the chosen comparison.

EXPERIMENTS Y534 AND H1

Experiment Y534 was established at the same time as Experiment Y536 and under the prevailing soil and weather conditions chemical activity against the same weed species was generally good. The only notable exceptions were pre-emergence applications of propachlor which failed to control twincress and the lower dose, 1 lb/acre, of phenmedipham which gave inadequate control of willow weed when applied at the four-true-leaf stage, prior to branching (see Fig. 3). After the first weed assessment, the beet were thinned, and before appreciable weed competition occurred control plots and those treated with phenmedipham, 1 lb/acre were weeded. The lenacil 1 lb/acre treatment subsequently became infested with willow weed. Failure to control twincress combined with an unacceptable level of crop damage led to a decision to discard both propachlor treatments for yield estimations and these plots subsequently became very weedy.

In the corresponding Experiment H1, carried out in Hawke's Bay, the natural weed density was in the range 5 to 10 plants per square foot, much lower than at Levin. The main weeds were: fathen, fumitory, redroot, henbit (*Lamium amplexicaule*) and shepherd's purse (*Capsella bursa-pastoris*). Weaknesses of herbicide treatments with regard to these weeds is shown in Fig. 3. The two latter species were the commonest weeds on the site and, excluding the resistance of henbit to both lenacil 1 lb/acre and pyrazon 3 lb/acre, they were well controlled by all other treatments.

Assessment of the effect of treatments on beet vigour in both experiments is summarized in Fig. 3. Propachlor treatments, especially the granular application and the higher dose, 2 lb/acre, of phenmedipham were damaging. The effect of phenmedipham was particularly marked at the Hawke's Bay site. In addition, at Levin the combination treatments of lenacil plus pyrazon and pyrazon plus phenmedipham also affected the vigour of the crop to some extent.

Table 2 gives details of yields of beet from Experiment Y534. Pyrazon 3 lb/acre and phenmedipham 1 lb/acre, both separately and in combination, gave total yields equal to the control level of 17.1 tons/acre. The

lenacil 1 lb/acre was affected by weed competition. All chemical treatments tended to increase the proportion of the yield in the small and medium size grades with a corresponding reduction of larger beets. Experiment H1 was mechanically harvested and, owing to the requirement of the canning industry, the machine was constructed to collect only a selected grade of beets. Thus, total beet yields were not obtained and, in the 2 to 3½ in. grade which was harvested and yielded an average of 8.4 tons/acre, there were no statistically different results, although the phenmedipham 2 lb/acre treatment in particular gave a rather low yield.

FIG. 3: Experiments Y534 and H1. Summary of assessments of beet and weed vigor (0 = maximum effect, absence of almost all plants. 10 = full plant vigor).

DISCUSSION

The experiments reported here covered both good and bad conditions for the activity of residual chemicals. In moist and warm seedbeds, both lenacil and pyrazon performed according to expectation and the sum of experience was that the tolerance of both red and silver beets was adequate at the doses applied. In combination, these chemicals led to some slight reduction in plant vigour. Willow weed showed resistance to lenacil and fathen survived pyrazon treatment.

The newer residual chemicals showed little promise. In the case of cycloate this may in part be due to inactivity under dry soil conditions. Both bensulide and propachlor caused unacceptable crop damage. It was noted that fathen was susceptible to bensulide. Twincrest was resistant and, in the same family, shepherd's purse was susceptible to propachlor.

Phenmedipham at 1 lb/acre gave good control of emerged weeds, even willow weed, when applied early. Twincrest is an important market garden weed which was controlled by all phenmedipham treatments.

Combination treatments of pyrazon or lenacil, with phenmedipham did not affect crop tolerance. There are problems of compatibility with phenmedipham and pyrazon but seemingly not with lenacil, and mixtures of phenmedipham 1 lb/acre with lenacil at $\frac{1}{2}$ or 1 lb/acre showed promise.

If soil conditions are favourable, a pre-emergence application of pyrazon (particularly if *Polygonum* spp. weeds are anticipated) or lenacil, followed by phenmedipham is worth considering. Alternatively, a single post-emergence application of a phenmedipham/lenacil mixture can be suggested, or, again, carefully timed successive phenmedipham treatments could provide season-long weed control. If the early phenmedipham sprays in Experiments Y534 and Y536 had been followed by a later application, satisfactory weed control would probably have been maintained until harvest. Further work on these lines will be carried out in 1969-70.

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