REDUCED-RATE HERBICIDE SEQUENCES IN BEETROOT PRODUCTION

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Summary Weed management in beetroot is costly; current herbicide strategies are expensive, do not provide reliable control and occasionally cause significant crop damage. Sugarbeet producers in the USA and Europe sequentially apply beet herbicides at low rates, with less risk of crop damage and at reduced costs.

In a 1995 experiment at Gatton Research Station, we sprayed 4-true-leaf beetroot with a mixture of 0.78 kg ha^{-1} of phenmedipham and 1.00 kg ha^{-1} of ethofumesate as the current commercial recommendation. Compared to a hand-weeded control, this reduced beetroot yields by 25%. Spraying 0.31-0.39 kg ha^{-1} of phenmedipham when beetroots had cotyledons and 2-true-leaves, followed by another 0.31 kg ha^{-1} one week later, yielded 87% of the hand-weeded beetroots. The most effective strategy involved applying 0.39 kg ha^{-1} phenmedipham mixed with 0.1 kg ha^{-1} ethofumesate, when the beetroot had two true leaves, followed by 0.24 kg ha^{-1} phenmedipham mixed with 0.1 kg ha^{-1} ethofumesate one week later. This treatment yielded 97% of the hand-weeded beetroots, while providing control of fat hen (*Chenopodium album*), deadnettle (*Lamium amplexicaule*), sowthistle (*Sonchus oleraceus*) and burr medic (*Medicago polymorpha*) equivalent to that achieved with the commercial treatment.

Compared to the commercial standard, sequences of phenmedipham/ethofumesate mixtures applied at low-rates increased profit by about $A485 ha^{-1}, due primarily to less phytotoxicity, but also lower herbicide costs.

INTRODUCTION

The cost-price squeeze has adversely affected profitability of fresh and processing beetroot production. Weed management in beetroot is costly; current herbicide strategies are expensive, do not provide reliable control and occasionally cause significant crop damage. Beetroot producers are concerned about long-term residues from some herbicides (R. Hawley personal communication). Sugarbeet producers in the USA and Europe have successfully applied low rates of beet herbicides sequentially, with less risk of crop damage and at lower costs (Anon. 1990, Dexter 1994, Griffiths 1994).

In previous experiments I found sequential low-rate strategies enabled earlier weed control, with less risk of crop damage, at lower costs (C. Henderson unpublished data). The experiment reported here investigated the efficacy and phytotoxicity of low rates of post-emergence herbicides in beetroot production.

MATERIALS AND METHODS

I conducted the experiment, comprising five replicates of nine weed management treatments, on a black earth soil at the QDPI Gatton Research Station in south-east Queensland. Beetroots (cv. Early Wonder Tall Top) were sown on 30 March 1995, in rows 0.75 m apart, with intra-row spacings of 0.05 m. Apart from weed treatments, beetroot were grown using standard agronomy.

Weed management treatments I used the registered beet herbicides phenmedipham (Betanal®) and ethofumesate (Tramat®) in this experiment. Phenmedipham is used for broadleaf weed control, and is known to cause crop damage where temperatures exceed 32°C (Anon. 1996). Ethofumesate is used both pre- and post-emergence. Some producers are concerned ethofumesate may occasionally injure beetroots at registered rates, as well as have adverse effects on following crops.

I applied the herbicides with a motorized knapsack sprayer. The 1.5 m wide hand-held boom had 110° flat-fan nozzles spaced 0.30 m apart. It was operated at 200 kPa and sprayed 250 L ha^{-1}. Weather at each spraying time is shown in Table 1. Weed management treatments are detailed below.

Beetroot with fully expanded cotyledons, 13 days after sowing (DAS):

1. (BcL) Phenmedipham at 0.24 kg ha^{-1}, followed by 0.24 kg ha^{-1} 7 days later.
2. (BcM) Phenmedipham at 0.31 kg ha^{-1}, followed by 0.31 kg ha^{-1} 7 days later.
3. (BcH) Phenmedipham at 0.39 kg ha^{-1}, followed by 0.31 kg ha^{-1} 7 days later.

Beetroot with 2-true-leaves, 20 DAS:

4. (B2L) Phenmedipham at 0.39 kg ha^{-1}, followed by 0.24 kg ha^{-1} 7 days later.
5. (B2H) Phenmedipham at 0.39 kg ha^{-1}, followed by 0.39 kg ha^{-1} 7 days later.
6. (BTL) Phenmedipham at 0.39 kg ha^{-1} mixed with ethofumesate at 0.1 kg ha^{-1}, followed by 0.24 kg ha^{-1} of phenmedipham mixed with 0.1 kg ha^{-1} of ethofumesate sprayed 7 days later.

Beetroot with 4-true-leaves, 27 DAS:

7. (B5) Phenmedipham at 0.78 kg ha^{-1}.

8. (BT5) Phenmedipham at 0.78 kg ha^{-1} mixed with ethofumesate at 1.00 kg ha^{-1} standard commercial treatment).
9. (HW) This treatment was hand weeded once only on 9 May 1995, 40 DAS.

Measurements and data analyses We measured the heights of five randomly selected beetroot plants from each plot 56 DAS. Nine metres of beetroot row were hand-harvested for yield from each plot on 21 June 1995, 83 DAS. We graded beetroots into small, medium and large classes, counted and weighed them. Weeds removed by hand weeding on 9 May were separated into species, counted and weighed. Five days before beetroot were harvested, we collected weeds from the central 9 × 0.75 m of each plot, sorted, counted and weighed them.

Table 1. Weather conditions at each spray application.

Date	Days after sowing	Beetroot growth stage	Temp/RH
12/4/95	13	Expanded cotyledons	11°C/70%
19/4/95	20	2 true leaves	18°C/65%
26/4/95	27	4 true leaves	20°C/85%

Beetroot growth and yield variables were analysed using standard analysis of variance. Owing to the nature of their distributions, weed counts and weights were log-transformed before analysis. The transformed data were converted back to normal values prior to presentation in tables and figures.

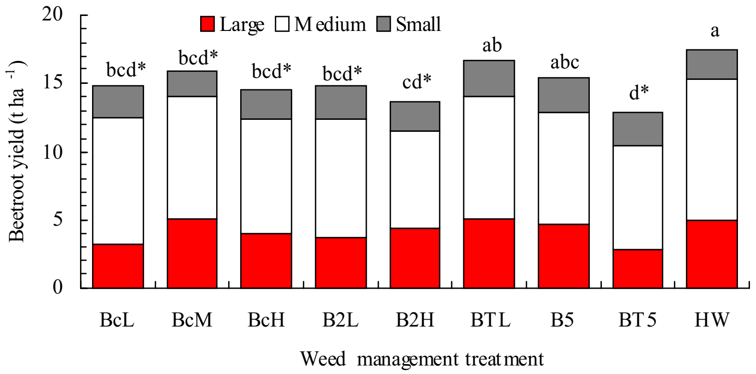

Figure 1. Weed management treatments affect yields of beetroot. Treatments with the same lettering are not significantly different; those followed by an asterisk are significantly less than the hand-weeded yields.

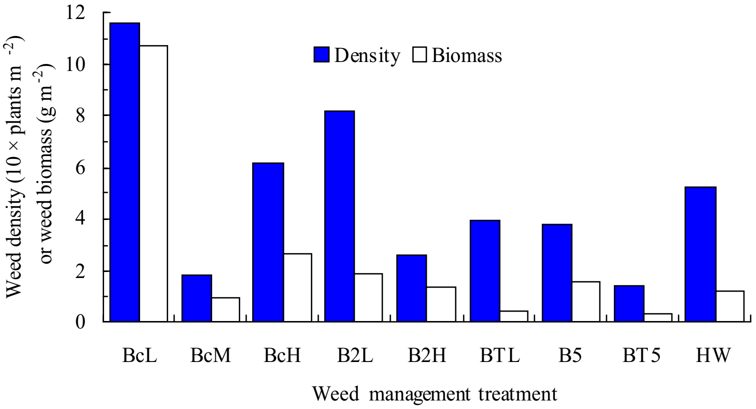

Figure 2. Weed management affects densities and biomass of weeds just before harvesting a beetroot experiment.

RESULTS AND DISCUSSION

Only 59 mm of rain fell during the experiment; the bulk in a 30 mm event just before harvest. Due to the prolonged drought, only minimal irrigation was available, and was probably sub-optimal. Water stress five weeks after sowing may have restricted leaf area and hence biomass and yield development.

Beetroot growth and yield There were very few weeds in this experiment; differences in beetroot growth or yields were due to phytotoxic effects from the herbicide treatments. Beetroots sprayed with 0.78 kg ha^{-1} of phenmedipham mixed with 1.00 kg ha^{-1} of ethofumesate were significantly shorter (4 cm) than hand-weeded plants 56 DAS. There were consistent trends for all other herbicide-treated plots (apart from those sprayed with phenmedipham/ethofumesate at low rates), to be about 2 cm shorter than hand-weeded beetroots.

Hand-weeding gave the highest total beetroot yields of all weed management strategies (Figure 1). Areas sprayed with low-rate phenmedipham/ethofumesate mixtures (when the beetroots had two true leaves), or 0.78 kg ha^{-1} of phenmedipham (when the beetroots had four true leaves), yielded similarly to the hand-weeded plots. Treatments sprayed when beetroots had expanded cotyledons, as well as the B2L and B2H treatments, yielded about 2.5 t ha^{-1} less. The lowest yielding plots were those sprayed with the commercial standard of 0.78 kg ha^{-1} phenmedipham + ethofumesate at 1.00 kg ha^{-1}. These areas produced 4.5 t ha^{-1} less beetroot than the hand-weeded plots (Figure 1). Lower yields were due to fewer large and medium size beetroots.

Weed control Weed species present in the experimental area included burr medic (*Medicago polymorpha*), sowthistle (*Sonchus oleraceus*), fat hen (*Chenopodium album*), deadnettle (*Lamium amplexicaule*), bittercress (*Coronopus didymus*), amaranthus (*Amaranthus* spp.), common pigweed (*Portulaca oleracea*) and various grasses. Only the first four species consistently occurred across the experiment. At the time of hand-weeding (40 DAS), there were few weeds present. Although burr medic, sowthistle, deadnettle and fat hen occurred in roughly similar numbers, fat hen, and to a lesser extent sowthistle, produced the bulk of the biomass.

Just before the beetroots were harvested, the numbers and biomass of weeds were still very low; less than 1 weed m^{-2} on average (Figure 2). Because of low weed numbers, conclusions as to efficacy against each species are difficult to establish. All herbicide treatments gave commercially acceptable weed control, with weeds present at beetroot harvest small, non-competitive, and non-contributors to the weed seedbank. Only in the BcL plots was there more than 3 g m^{-2} of weed biomass. In situations of greater weed burdens, this treatment may not provide sufficient weed suppression.

CONCLUSIONS

In this experiment, drought-induced difficulties with irrigation (both quality and quantity), probably led to establishment and growth limitations on beetroot yields. However, I believe comparisons between weed management strategies are still valid. The commercial standard of applying 0.78 kg ha^{-1} phenmedipham + ethofumesate at 1.00 kg ha^{-1} when beetroots have fourt rue leaves significantly reduced growth and yields of beetroot. In this experiment (contrasting with a previous study at Gatton Research Station), when ethofumesate was removed from the commercial mixture, the phytotoxic effect also largely disappeared. Low-rate sequences of phenmedipham, whether applied at the cotyledon or 2-true-leaf stages, all caused slight growth and yield depressions (compared to hand-weeded areas). Interestingly, the best performed herbicide treatment, with least beetroot damage and most effective weed control, was where low rates of phenmedipham and ethofumesate were sprayed at the 2- and 4-leaf-stages of the crop (BTL). Apart from where phenmedipham was sprayed at the lowest rate (BcL), all herbicide treatments gave weed control equivalent to hand-weeding.

Assume the pre-emergence and early post-emergence applications are only sprayed over the central third of each beetroot row, and that inter-row weeds are controlled by cultivation. Taking into account relative herbicide costs and beetroot yield differences, an economic analysis of this experiment shows:

a. Removal of ethofumesate from the commercial treatment increased profit by \$A340 ha^{-1},
b. Low rate herbicide sequences reduced weed control costs 50–60%,
c. Spraying phenmedipham sequences at low-rates when beetroot had up to two true leaves increased profit by \$A250–420 ha^{-1},
d. Addition of 0.1 kg ha^{-1} of ethofumesate to the early post-emergence sprayings increased profits by \$A485 ha^{-1} compared to the commercial standard. Profit increases were largely due to less crop damage from the low-rate herbicide treatments, although there was about a \$A60 ha^{-1} contribution from reduced weed control costs.

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