Determination of yield and herbicide residues in asparagus spears after treatment with some post-emergence herbicides

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Summary
Four post-emergence herbicides were applied during the harvest season to an established asparagus crop. The spears were harvested every alternate day for 3 weeks after treatment, counted, assessed for quality and production, and analysed in the laboratory for presence of herbicide residues. The suggested use rates of clopyralid and dicamba caused little damage to spears and their residues in the spears declined quickly. Amitrole was slightly more damaging and its residues were detectable in spears for up to 7 days after treatment. Glyphosate caused severe damage to the treated spears, but those emerging after the spray application did not show any significant damage and residues in these spears declined below detectable levels within 5 to 7 days after treatment. The suggested use rates of these herbicides did not appear to have any long term effects on the asparagus crop.

Introduction

Satisfactory season-long weed control is a major problem of asparagus (*Asparagus officinalis* L.) crops, particularly in the mild, high rainfall regions of New Zealand. Managing weeds in this crop is best done by a combination of herbicides and cultivation. Asparagus growers in this country have a large choice of residual herbicides for general weed control (3, 5), but these do not control some perennial weeds such as Californian thistle (*Cirsium arvense* (L.) Scop.) and field bindweed (*Convolvulus arvensis* L.). These two weeds have a growth habit similar to that of asparagus, with new shoots appearing in the spring. They also grow quickly to severely impede harvesting of spears and compete with the crop to reduce spear production.

Field trials by Rahman and Sanders (4) indicated some herbicides which may be used at the close up stage of the crop for control of these weeds. They are most troublesome, however, during the harvesting season when no herbicide use was permitted, because of the lack of information about their effects on the crop and their residues in the spears. This work was therefore conducted to determine the effect of four post-emergence herbicides on the production of spears and their residues in spears harvested in the first few days after treatment.

Materials and methods

The field trials were conducted at the Rukuhia Horticultural Research Station near Hamilton on a Horotiu sandy loam soil (Organic C 8.9%; pH 5.6). The established crop of asparagus cv UC72 was in its third season of growth and had received a pre-emergence residual treatment of 1.6 kg ha^{-1} bromacil 3 days before the harvesting season (initiated on 12 September 1984). The post-emergence herbicides were applied on 10 October 1984 during the harvest period, following a normal harvest. The plot size was 20 m x 3 m, encompassing two asparagus rows, with treatments arranged in a randomised block design and replicated four times.

The herbicide treatments (Table 1) were applied in 200 L ha^{-1} water at 175 kPa with a precision plot sprayer. The lower rate of each herbicide was the recommended rate or the rate most likely to be used for control of Californian thistle and bindweed.

Asparagus spears were harvested every alternate day for 3 weeks after treatment, counted, trimmed to 150 mm length and the fresh weight from each plot was recorded. The harvests were graded as for a commercial crop and any abnormalities of spears which would render them into second grade or reject categories were recorded. The fresh weight of fern at the end of growing season (June 1985) was also recorded. The field trial was repeated in the next growing season with the same four herbicides applied on 31 October and spears were harvested for 24 days.

A representative sample of spears from each plot was analysed, in duplicate, for determination of herbicide residues. Analytical procedures for clopyralid and dicamba, utilising reversed-phase high-performance liquid chromatography (HPLC), have been described previously (2). For analysis of amitrole, the samples were extracted with acetonitrile and the macerate filtered through celite. The filterates were evaporated and redissolved in water. The aqueous solutions were derivatised and analysed by HPLC as described by Archer (1). For glyphosate, the samples were extracted with a water + chloroform mixture. An aliquot of the aqueous extract was cleaned up and derivatised for reversed-phase HPLC analysis with fluorescence detector by a method developed in our laboratory.

Results and discussion

There were no significant differences between treatments in total spear numbers, average spear weight and total gross or trimmed weight of spears harvested over the 3-week period (Table 1). However, the spears present at the time of treatment with glyphosate were severely damaged, resulting in a high proportion being graded as rejects. For both rates of glyphosate and the high rate of amitrole, the number of spears classed as second grade, or showing some damage, was significantly greater than the control. The damage consisted of bent spears, small or retarded spears as well as open heads in the case of amitrole. The proportion of spears damaged by the suggested use rate (i.e. the low rate) of clopyralid, dicamba and amitrole was minimal (Table 1). In all the treatments, however, spears emerging after the herbicide application were not affected adversely and the proportion of saleable spears was similar to the control.

In a separate field experiment with glyphosate (1.44 and 2.88 kg ha^{-1}), every spear present at the time of spraying was tagged and followed until harvested. Results showed that of the tagged spears nearly 60% and 72% were graded as rejects in the 1.44 and 2.88 kg ha^{-1} glyphosate treatments respectively. The spears emerging after spraying (untagged spears) showed a slight reduction in saleable numbers and total weight produced, but these differences were not statistically significant.

Analyses of herbicide residues showed that at suggested use rates no detectable residues were present in spears harvested on day 5 for clopyralid and on day 7 for the other three herbicides. At higher use rates the residues were present in higher amounts but persisted for longer time only in some cases (Table 2).

Table 1. Effect of herbicides applied during cutting season on production and quality of asparagus spears and fresh weight of ferns.

Herbicide	Rate (kg ha^{-1})	Spear no.	Spear yield	Av. spear weight	Fern weight	Spear damage	Reject spears
		% of control†				% of total†	
Clopyralid	0.21	99.5	103.3	105.9	94.2	0.1	4.2
	0.42	99.9	97.8	102.8	97.2	1.9	3.1
	0.63	91.1	87.4	91.5	93.1	5.7	6.6
Dicamba	0.40	95.7	100.8	105.8	99.2	1.6	5.2
	0.80	89.6	89.8	92.8	95.5	4.6	6.5
Amitrole	4.0	101.8	90.1	95.0	98.3	2.3	2.3
	8.0	89.2	82.1	94.2	97.8	9.5	9.1
Glyphosate	1.44	96.3	87.3	98.0	92.2	16.6*	8.3
	2.88	86.5	82.8	93.7	94.1	18.9*	8.6
CV %		16.9	23.4	11.3	9.9	14.1	21.6

† The control consisted of two applications of diuron (2.0 kg ha^{-1}) + hand-weeding. All the data are based on the total spears harvested over the 3-week experimental period.

* Significantly different from control (P = 0.05); all other results are not significantly different from control.

In a separate experiment with glyphosate, analysis of spears which emerged on days 1, 2, 3 and 5 after spray application showed a chemical concentration of only 0.67, 0.33, 0.19 and <0.01 mg kg^{-1} respectively. In contrast the sprayed spears (rejects) harvested on days 3 and 5 had a concentration of 3.02 and 0.71 mg kg^{-1} respectively. The stage at which the spears treated with any of the above herbicides could be harvested for human consumption, would depend on the maximum residue limit (MRL) set for the herbicide in various countries. Dicamba, for example has an MRL in asparagus of up to 3.0 mg kg^{-1} in some countries.

Table 2. Herbicide concentrations (mg kg^{-1}) in asparagus spears harvested at different intervals after spraying.

Herbicide	Rate (kg ha^{-1})	Days after treatment					
		1	3	5	7	9	11
Clopyralid	0.21	0.15	0.08	<0.03			
	0.42	0.20	0.17	<0.03			
	0.63	0.45	0.30	0.06	0.06	<0.03	
Dicamba	0.40	0.54	0.51	0.18	<0.07		
	0.80	1.03	0.85	0.50	0.13	<0.07	
Amitrole	4.0	6.53	2.20	0.60	<0.02		
	8.0	9.53	5.73	1.00	0.11	0.02	<0.02
Glyphosate*	1.44	0.89	0.73	0.04	<0.01		

* Spears treated with high rate of glyphosate not analysed.

In conclusion it appears that the suggested use rates of clopyralid and dicamba cause little damage to spears treated and their residues in the spears decline quickly. Clopyralid has now been registered in New Zealand for use during cutting season at a rate of 0.15 kg ha^{-1} with no harvesting permitted within 3 days of treatment. Additional investigations have shown that residues in spears from plots treated with this rate fall below detectable levels in 2 to 3 days after spraying. Amitrole is slightly more damaging and because of its higher use rate its residues remain in higher concentrations, although for only a maximum of 7 days. Glyphosate caused severe damage to treated spears but most of these were classified as rejects and would not normally be harvested. By the time any partially affected spears attain saleable dimensions (length and volume), the concentration of glyphosate in them would decline considerably. The low rate of these herbicides used during the cutting season did not appear to have any long term effects on the asparagus plants.

References

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