ASSESSMENT OF HERBICIDE RESIDUES IN FIELDS OF ESTABLISHED ASPARAGUS

A. RAHMAN and P. SANDERS

MAF Technology North, Ruakura Agricultural Centre, Private Bag, Hamilton

SUMMARY

Soil samples collected in August from 31 fields of established asparagus crops around the Waikato were bioassayed in the glasshouse using three test species. In general, visual damage to the bioassay species and the effects on dry matter production were higher in fields treated with terbumeton/terbuthylazine than those where bromacil was used. Of the 31 sites, only 4 did not have any residues that were phytotoxic to sensitive crop species. Thus 87% of the sites sampled had sufficient biological activity to injure the bioassay species, suggesting the possibility of susceptible crops being damaged if planted in spring/early summer, a year after the application of residual herbicides.

INTRODUCTION

With the aging of many asparagus beds and the rising price of land, a need is arising now for use of asparagus fields for other agricultural or horticultural purposes. However, an established asparagus block cannot be used for a different purpose unless methods are developed to successfully remove the existing crop and the status of herbicide residues in the soil and its possible effects on subsequent crops are known.

Residual herbicides are currently used by most asparagus growers in New Zealand to achieve weed-free crops. In established crops two or more residual herbicides or their combinations are used each year, most of which have long residual activity in the soil (Rahman 1986). This list includes the herbicide bromacil which is used widely in asparagus crops in New Zealand, but is registered for this purpose in very few other countries. Being a very active and persistent chemical, it can affect the germination and growth of many crops, including newly sown asparagus, at small concentrations (Rahman *et al* 1981).

The objective of this work was to assess if biologically active levels of residual herbicides are present in early spring in established fields of asparagus. This is necessary information in planning the subsequent land use of asparagus beds.

MATERIALS AND METHODS

Soil samples were obtained from 31 fields of established asparagus on 21 separate properties located in different parts of the Waikato. Samples taken from the same property were from separate fields which had different soil types or different herbicide programmes. The soil type in general was of volcanic parent material; the texture varied from sandy to sandy silt loam, and the organic C levels were between 7 and 10%.

Ten samples were collected from each field on a diagonal transect with a spade to a depth of 15 cm. Two additional samples of untreated soil were taken at each site from the nearest possible land area which had not received any residual herbicides. Untreated soil from a representative Horotiu sandy loam was also collected to serve as an extra control.

The sampling was done in August, 1989, approximately 11 months after pre-emergence applications and 8 months after the close-up treatments were applied to these fields. This allowed the near-maximum time for degradation of herbicides used in the previous season.

All soil samples were brought to the glasshouse and bioassayed using the procedure described earlier (Rahman 1977). Each sample was thoroughly mixed and transferred into three 12 cm diameter plastic pots which were planted with either oats (*Avena*

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sativa), radish (*Raphanus sativus*) or German millet (*Setaria italica*). Thus each field site had ten replications (and two untreated replications) of each species. Twenty seeds of each species were planted at 20 mm depth and thinned to 15 plants soon after emergence and before any herbicidal effects were apparent.

For the duration of the trial the pots were sub-irrigated every 2-3 days as required to maintain the soil moisture level near field capacity. Plants were assessed visually to determine the extent and type of herbicide damage. After growing for 4-5 weeks the surviving plants were harvested for dry matter determination. For comparison and quantitative estimation purposes a series of 'standards' was established in the Horotiu sandy loam soil by using a range of concentrations of the two most widely used residual herbicides, viz. bromacil (Hyvar) and terbumeton/terbuthylazine (Caragard). The required herbicide concentration was mixed with the soil throughout the pot and its effect on plant growth and dry shoot weight of the bioassay species was determined.

RESULTS AND DISCUSSION

The residual herbicides applied in the 1988-89 season in fields sampled for study are listed in Table 1. About 61% of the fields (sites) received only a pre-harvest application of terbumeton/terbuthylazine or bromacil (Programme A or C respectively). Of the 13 sites treated with terbumeton/terbuthylazine, 10 were treated with the maximum recommended rate of 5.0 kg/ha, and the remainder received only 75% of that rate. The rates of bromacil used were between 1.6 and 2.0 kg/ha, with the lower rate also applied as a mixture with diuron (as Krovar). Approximately 39% of the sites received a second herbicide application at close-up in addition to the pre-harvest treatment (Programmes B, D and E).

TABLE 1: Residual herbicide programmes for the 1988-89 season at the sites from which soil samples were taken.

No. of sites	Programme	Herbicide used at pre-harvest	close-up	Total amount (kg ai/ha)
13	A	terbumeton/ terbuthylazine	—	3.8-5.0
3	B	terbumeton/ terbuthylazine	terbumeton/ terbuthylazine	5.0-8.0
6	C	bromacil	—	1.6-2.0
5	D	bromacil*	bromacil*	2.0-3.6
4	E	bromacil/diuron**	diuron	1.6-2.0†

* One site had bromacil + diuron at both times of application.
** One site had bromacil only at pre-harvest.
† Rate of bromacil only; diuron rate was 1.6 kg ai/ha.

Of the three test species used for bioassay of herbicide residues, oats were found to be the most sensitive to both bromacil and terbumeton/terbuthylazine, while German millet was the least susceptible species. The damage and dry matter data presented are for oats and radish only because damage to German millet was recorded in only a few cases.

The extent of damage to oats and radish recorded in soil samples from the various sites is presented in Table 2. In addition to the average figures, the range of damage levels are also presented to give an appreciation of the variation observed between different sites. The results show that both the visual damage to bioassay species and the reductions in their dry matter production were generally higher in samples from fields treated with terbumeton/terbuthylazine (Programme A and B) than those where bromacil (C, D and E) was used for weed control. Residual activity was highest in sites where terbumeton/terbuthylazine was used twice in the season (pre-harvest and close-up). The figures are exaggerated by extremely high activity at one site which received a total dose of 8 kg/ha (5 kg/ha at pre-harvest and 3 kg/ha at close-up).

Visual herbicide damage levels in samples receiving the commercial mixture of bromacil + diuron were similar to those observed in bromacil only treatments. For this reason the diuron additive has been disregarded and all these sites have been considered as having used the bromacil programme. The additional treatment of diuron at close-up (Programme E) also did not increase the level of residual activity (Programme C cf. E, Table 2). Slightly lower levels of damage were recorded in Programme D where two applications of bromacil were made and the total dosage used was the same or higher than programmes C and E. A cursory look at various soil and climatic factors did not reveal any differences which could explain this result. The possibility that the degradation rate of bromacil may be enhanced as a result of the two split applications is a question which would need further investigation. This trend was not noticed in the case of terbumeton/terbuthylazine where the sites receiving two applications exhibited similar or higher residual activity compared to a single application (Programme A cf. B). Results from the two test species showed similar damage trends and these visual observations were well supported by dry matter yield data, although the reduction in dry matter was usually higher than the damage estimated visually.

Of the 31 sites used in this study, soil samples from only four sites did not exhibit any measurable residual activity — either through visual symptoms or through dry matter yield reductions. Three of these sites were treated with bromacil and one with the bromacil/diuron mixture. Thus 87% of the sites sampled had sufficient biological activity from the residual herbicides used for weed control to injure the susceptible bioassay species.

TABLE 2: Visual damage and dry matter yields of bioassay species in soil samples collected from fields using different herbicide programmes.

Herbicide* programme used	Oats				Radish			
	% damage		DM (% of control)		% damage		DM (% of control)	
	range	average	range	average	range	average	range	average
A	26-80	53	7-59	24	0-69	38	12-81	45
B	77-100	89	0-19	11	74-96	87	5-30	14
C	15-67	26	16-80	55	8-52	26	29-92	65
D	3-19	15	48-104	75	10-15	11	66-103	89
E	26-45	25	17-69	53	25-40	26	35-82	61

*For herbicide programme used refer to Table 1.

The effects of known concentrations of bromacil and terbumeton/terbuthylazine in the glasshouse 'standards' on oats, radish and subterranean clover are shown in Table 3. A comparison of these data with the dry matter reductions recorded in soil samples collected from asparagus fields (Table 2) gives some indication of the range of concentrations which were still persisting nearly a year after the initial herbicide application. If the susceptibility of the species to be planted subsequent to asparagus crop removal is known, an assessment can be made about the likely success of its establishment. However, this will provide only a rough indication because the effect of the herbicide will vary with the soil type and environmental factors. Deep cultivation to mix the soil may not necessarily dilute the herbicide. A long term study with bromacil (Rahman and Sanders, unpublished) indicates that where residues of the herbicide are found after 1 year, they are present in the 150-300 mm depth in addition to the top 150 mm of the soil.

Although the level of residual activity may vary from season to season, the results presented here suggest that the presence of phytotoxic residues after nearly one year is a real possibility. There is a likelihood of susceptible crops being damaged if planted in spring/early summer, i.e. 1 year after the last herbicide application. The herbicide choice and the rate used in the last two years of the crop's life, weather conditions, soil type and the management factors imposed on the crop will all have some influence on the residual activity persisting in the soil.

TABLE 3: Effect of known concentrations of the two herbicides on dry shoot weight*, as a percentage of untreated, of bioassay species in the glasshouse.

Concentration (ppmw)**	bromacil			terbumeton/terbuthylazine		
	oats	radish	sub. clover	oats	radish	sub. clover
0.0	100	100	100	100	100	100
0.10	98	99	106	102	100	108
0.20	93	101	98	97	104	99
0.30	51	76	83	74	85	92
0.50	22	28	53	46	71	89
0.75	0	7	15	33	62	68
1.00		0	0	14	36	28
1.25				3	21	21
1.50				0	9	5
1.75					0	0
2.00						

* Blank spaces indicate bioassay plants killed.
** Parts per million by weight of oven-dry soil.

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