SOIL ACTIVITY AND PERSISTENCE OF THE SULFONYLUREA HERBICIDE PRIMISULFURON

A. RAHMAN, T.K. JAMES and T.M. PATTERSON*

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

*CIBA-GEIGY New Zealand Ltd, Private Bag, Auckland

SUMMARY

Several bioassay species were used to determine the activity of primisulfuron in the soil. The most sensitive of these, mustard (*Sinapis alba*) and annual ryegrass (*Lolium multiflorum*), showed that biological activity of the herbicide at rates down to 1 g/ha (approximately 0.001 ppmw) could be detected in the soil. Persistence of different rates of primisulfuron was determined in a field trial. Residues from 20 and 40 g/ha disappeared within 2 and 3 months respectively when using mustard as the bioassay species. Bioassays of soil samples collected from a number of maize fields at the end of the growing season did not show any measurable activity of primisulfuron.

INTRODUCTION

The sulfonylurea herbicide primisulfuron has recently been tested as a maize (*Zea mays*) herbicide in New Zealand. Developed by CIBA-GEIGY, it has provided excellent post-emergence control of *Sorghum* spp. in maize at 10-20 g/ha (Maurer *et al* 1987). It has also been found to adequately control *Xanthium* spp. and *Datura* spp. and most cruciferous weeds.

The mode of action of primisulfuron is typical of the sulfonylureas in that it is rapidly absorbed by the foliage (with some absorption through the roots) and translocated to actively growing meristematic tissues of both the foliage and roots, where it strongly inhibits cell division. Although growth is stopped immediately, desiccation takes 10-20 days under normal conditions.

Primisulfuron is only weakly adsorbed by soil components. Degradation in the soil is by a combination of microbial activity and chemical hydrolysis with predominance of either one being dependent on various soil properties. Other sulfonylurea herbicides have been shown to degrade principally via chemical pathways in acidic soils and via microbial pathways in alkaline soils (Beyer *et al* 1987). Both high soil moisture and temperature have been shown to reduce the half-life of the primisulfuron in the soil (Maurer *et al* 1987).

The half-life of primisulfuron was found to be 2 to 4 weeks in neutral to alkaline soils by Maurer *et al* (1987). However, most New Zealand soils are acidic, especially in the maize growing areas of the North Island and have comparatively high levels of organic matter. This paper describes the residual activity of primisulfuron in a Waikato sandy loam soil and discusses results from end of season bioassays for the chemical in soils from maize fields of both Waikato and Manawatu regions.

MATERIALS AND METHODS

Establishment of 'standards'

Glasshouse experiments were conducted to establish standard curves of the activity of known concentrations of primisulfuron (Beacon 75 WG, code number CGA 136'872) in the soil for a number of bioassay species. The test soil was a Horotiu sandy loam with 61% sand, 16% clay, 9.5% organic carbon and a pH of 5.7, collected from the site of the field persistence trial. The bioassay species tested were mustard, annual ryegrass, subterranean clover (*Trifolium subterraneum*), red beet (*Beta vulgaris* ssp. *vulgaris*), lentils (*Lens culinaris*) and radish (*Raphanus sativus*). A range of concentrations

Proc. 43rd N.Z. Weed and Pest Control Conf. 1990: 142-145

between 0.1 and 50 g/ha was used to establish a standard curve for each of the test species. The herbicide treatments were individually made up in volumetric flasks and then applied to the soil in 10-cm deep trays using a moving belt precision sprayer applying 300 litres/ha at 200 kPa. This soil was thoroughly mixed by shaking in a polythene bag and then used for potting out the test species. Further details of the procedure are given in Rahman *et al* (1988). Visual observations of plant damage were made throughout the experiments and the plants were harvested for dry matter yields 4 to 5 weeks after planting. These assessments were used to evaluate the effects of the herbicide.

Persistence of primisulfuron in the field

This trial was conducted at Rukuhia Horticultural Research Station, near Hamilton, in a maize (*Zea mays* cv. Pioneer 3709) crop grown on the Horotiu sandy loam soil described above. Individual plots were 10 x 3 m and were replicated four times in a randomised block design. Treatments (Table 2) were applied post-emergence on 5 December 1988 (33 days after planting) with a CO₂ powered precision sprayer delivering 300 litres/ha at 200 kPa, when the maize had four to six leaves.

Soil samples from the top 10-cm were collected from each plot of the trial, using a 7.5-cm diameter corer, on the day after treatment and at monthly intervals thereafter. The soil samples were brought to the glasshouse where they were thoroughly mixed and used to plant out one pot of each of the bioassay species. These were then grown and assessed as for the 'standards' above.

End of season bioassays

At the end of the growing season soil samples were collected from four field trials where primisulfuron was used at 22.5 and 37.5 g/ha for weed control in maize. Each trial was of a randomised block design with four replicates. The samples were taken from the top 10-cm of the soil from each of the treated and untreated plots and subjected to bioassays as described above. These trials, two in Waikato and two in Manawatu, were on a Puniu silt clay loam complex, a Kereone silt loam, a sandy loam and a Manawatu silt loam. Rainfall at each site was between 400 and 600 mm for the growing season.

RESULTS AND DISCUSSION

Establishment of 'standards'

Of the species tested initially, mustard, annual ryegrass and subterranean clover were selected as the most suitable bioassay species for primisulfuron. Mustard and annual ryegrass were shown to be as sensitive as lentils and red beet but emerged more evenly and produced more uniform growth. Radish was less sensitive than the other species. Subterranean clover was included because, like annual ryegrass, it represents species often planted after a crop of maize.

For the three bioassay species selected, dry shoot weight data from the experiments conducted with known rates of primisulfuron are presented in Table 1. The results demonstrate that mustard and annual ryegrass were more sensitive, showing significantly reduced growth from 1 g/ha (approximately 0.001 ppmw) of the herbicide. Subterranean clover was less susceptible, with 15 g/ha being the lowest rate to have any visible effect on the plants. In the case of mustard the first noticeable effect of the herbicide was a reduction in the number of lobes on the leaves. At higher rates the whole leaf was reduced to a small stump at the growing point of the plant. Because of this effect on the leaf, damage at low rates of primisulfuron was more easily detected by visual inspection than by dry matter determination. These damage symptoms have been reported also for other sulfonylureas (James *et al* 1988; Rahman and James 1989; James *et al* 1989; Rahman 1989) and appear typical of this group of herbicides. With annual ryegrass and subterranean clover the herbicide damage took on the form of reduced height or smaller leaves. At higher rates the leaves of subterranean clover were deformed like mustard but the plants still produced cotyledons (and hence some dry matter) whereas annual ryegrass either failed to emerge or only produced a very short shoot. This is reflected in the low dry matter weights for annual ryegrass at high concentrations.

TABLE 1: Effect of known rates of primisulfuron on bioassay species grown in the glasshouse ('Standard' series).

Primisulfuron (g ai/ha)**	Dry shoot weight* (% of untreated)		
	Mustard	Ryegrass	Sub. clover
0	100	100	100
0.1	97	94	107
0.5	92	92	95
1.0	78	75	97
2.5	67	61	92
5.0	50	48	107
7.5	44	45	105
10.0	43	36	98
15.0	37	22	79
25.0	28	5	72
50.0	17	1	61
SEM***	5.7	6.6	4.8

* Average of four 'Standards' conducted on 30.9.88, 23.11.88, 13.1.89 and 10.4.89.

** These rates were incorporated into 10 cm of soil (the same depth as the field sample cores) before planting the bioassay species.

*** SEM is averaged from those treatments yielding more than 50% of untreated.

Persistence of primisulfuron in the field

Dry shoot weights from the bioassay analysis of soil samples collected from the field trial are presented in Table 2. These show that the biological activity of primisulfuron could be detected in the soil for up to 2 and 3 months at rates of 20 and 40 g/ha respectively when using mustard as the test species. At the highest rate of 80 g/ha phytotoxic residues persisted in the soil for up to 4 months. Subterranean clover was unaffected by residues from the 20 g/ha rate on the day after treatment and by residues from the 40 and 60 g/ha rates at the end of the first month. Results for annual ryegrass were intermediate between those for mustard and subterranean clover.

The visual damage scores (not presented) gave the same results as the dry matter weights for mustard and annual ryegrass. Subterranean clover however, showed damage symptoms (assessed at 20%) in the first and second monthly samples of the 60 and 80 g/ha rates respectively, although there was a corresponding reduction in dry matter only at 80 g/ha after 1 month.

Rainfall over the duration of the trial was 60, 223, 76 and 32 mm respectively for the intervals between the monthly samplings. This relatively high rainfall, especially between 1 and 2 months after application, may have had some effect on the persistence of primisulfuron in the soil.

Using similar bioassay techniques Maurer *et al* (1987) showed that the half-life of primisulfuron in a variety of soils from clays to sands ranged between 17 and 30 days and they further reported that to date there have been no problems with end of season residues. This would indicate that this herbicide is only moderately persistent. Although the work reported here was not designed to determine the half-life of primisulfuron, the fact that all detectable residues (<1 g/ha) were gone within 4 months from the highest rate of 80 g/ha indicates that the half-life under local conditions is probably within a similar range.

End of season bioassays

Bioassays of soil samples collected from the maize fields at the end of the growing season did not show any detectable biological activity of primisulfuron. As the field trial sites provided a range of climate and soil characteristics of the maize growing areas of New Zealand, it can be safely predicted that the likely field application rates of primisulfuron would not result in residues sufficient to injure even the most susceptible follow-on crops.

TABLE 2: Bioassay of primisulfuron residues in 0-10 cm depth of Horotiu sandy loam soil — dry shoot weight as percent of untreated (= 100).

Rate (g ai/ha)	Months after spraying				
	0*	1	2	3	4
Mustard					
20	21	81	<i>120**</i>	<i>90</i>	<i>95</i>
40	11	47	85	<i>94</i>	<i>92</i>
60	8	21	75	<i>105</i>	<i>106</i>
80	6	12	79	<i>74</i>	<i>91</i>
Ryegrass					
20	33	<i>114</i>	<i>96</i>	<i>98</i>	<i>102</i>
40	22	<i>101</i>	<i>97</i>	<i>99</i>	<i>107</i>
60	2	61	<i>88</i>	<i>105</i>	<i>106</i>
80	0	47	<i>78</i>	<i>94</i>	<i>101</i>
Sub. clover					
20	<i>92</i>	<i>119</i>	<i>92</i>	<i>85</i>	<i>108</i>
40	51	<i>118</i>	<i>94</i>	<i>98</i>	<i>95</i>
60	42	<i>97</i>	<i>106</i>	<i>120</i>	<i>104</i>
80	52	73	<i>93</i>	<i>112</i>	<i>95</i>

* Sampled the day after spraying.

** Figures in italics are not different from untreated controls (= 100), ($P=0.05$). In samples collected 5 months after application there were no significant differences between shoot weights.

CONCLUSION

From the results of the persistence trial it appears that at field use rates, primisulfuron would not leave any phytotoxic residues in the soil at the end of the growing season. This conclusion is supported by the results of the end of season bioassays which all showed negative results.

ACKNOWLEDGEMENTS

We would like to thank Eric Beetz and George Follas for providing soil samples from their field trials and Judy Mellsop for technical assistance in planting out and looking after the glasshouse experiments.

REFERENCES

- Beyer, E.M., Brown, H.M. and Duffy, M.J., 1987. Sulfonylurea herbicide soil relations. *Proc. 1987 British Crop Protection Conf. — Weeds*: 531-547.
- James, T.K., Rahman, A. and Patterson, T.M., 1988. Residual activity of triasulfuron in several New Zealand soils. *Proc. 41st N.Z. Weed and Pest Control Conf.*: 21-25.
- James, T.K., Rahman, A. and Mortimer, J., 1989. Biological activity of DPX-L5300 in some New Zealand soils. *Proc. 42nd N.Z. Weed and Pest Control Conf.*: 91-94.
- Maurer, W., Gerber, H.R. and Rufener, J., 1987. CGA 136'872: a new post-emergence herbicide for selective control of *Sorghum* spp. and *Elymus repens* in maize. *Proc. 1987 British Crop Protection Conf. — Weeds*: 41-48.
- Rahman, A., James, T.K. and Mortimer, J., 1988. Persistence and mobility of the sulfonylurea herbicide DPX-L5300 in a New Zealand volcanic soil. *Mededelingen van Rijksfaculteit Landbouwwetenschappen Gent*. 53: 1463-1469.
- Rahman, A., 1989. Sensitive bioassays for determining residues of sulfonylurea herbicides in soil and their activity on crop plants. In: M. Munawar, G. Dixon, C.I. Mayfield, T. Reynoldson and M.H. Sadar (eds), *Environmental Bioassay Techniques and their Application. Hydrobiologia 188/189*: 367-375.
- Rahman, A. and James, T.K., 1989. Comparative mobility of nine sulfonylurea herbicides in soil columns. *Proc. 12th Asian-Pacific Weed Sci. Soc. Conf.*: 213-217.