CROP SENSITIVITY TO RESIDUES OF THREE SULFONYLUREA HERBICIDES IN A SOIL-FREE SYSTEM

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Summary At present information is limited on the response of crops to doses of sulfonylurea herbicides, which are used extensively in the north-eastern grain growing region. A soil-free system was used to determine the response of barley (*Hordeum vulgare*), canola (*Brassica napus*), chickpea (*Cicer arietinum*), cotton (*Gossypium hirsutum*), mungbean (*Vigna radiata*), sorghum (*Sorghum bicolor*), sunflower (*Helianthus annuus*), and wheat (*Triticum aestivum*) to different concentrations of the chlorsulfuron, metsulfuron methyl, and triasulfuron. Logistic curves were fitted to the data (shoot fresh weights) to derive the ID_{10}, ID_{30}, and ID_{50} values, the herbicide concentrations that inhibit 10, 30 and 50% of seedling growth. Sunflower was the most susceptible crop to all the sulfonylurea herbicides, with ID_{50} values of 0.46, 0.14, and 0.29 µg L^{-1} for chlorsulfuron, metsulfuron methyl, and triasulfuron respectively. Mungbean was the most tolerant summer crop to chlorsulfuron (ID_{50} 0.96 µg L^{-1}), and sorghum was the most tolerant to metsulfuron methyl (ID_{50} 0.77 µg L^{-1}) and triasulfuron (ID_{50} 1.40 µg L^{-1}). Wheat and barley were very tolerant to these herbicides. The crop sensitivity data are being used to evaluate results of field experiments that are predicting the safety of re-cropping under a range of environments.

INTRODUCTION

Sulfonylurea herbicides, including chlorsulfuron, metsulfuron methyl and triasulfuron, are used extensively in the winter cereal cropping area of Australia. Although these herbicides can provide cost-effective residual weed control, following susceptible crops can be damaged from the persistent residues. This is generally avoided when the currently recommended re-cropping intervals are followed. However, the long plant-back periods are thought to restrict their use and the choice of following crops in some environments.

Alternatively, Ferris and Haigh (1992) proposed that fixed re-cropping intervals could be replaced with a more flexible system of prescription recommendations that take into account local weather conditions, soil type and herbicide application rate. This aspect is currently being investigated for three sulfonylurea herbicides in the different environments within the grain region of Queensland (Walker *et al*. 1996). For this approach to be successful, data are needed on crop responses to the herbicide residues that may be measured or predicted in different soils prior to sowing. Whilst some of these data are available for European crops and herbicides (Ferris and Haigh 1992), little is known for the major crops of this region and the sulfonylurea herbicides. This paper presents data on the responses of eight crops to residues of three sulfonylurea herbicides when fully available to the whole root system.

MATERIALS AND METHODS

Crop responses to chlorsulfuron (as Glean 750 g a.i. kg^{-1}, Du Pont), metsulfuron methyl (as Ally 600 g a.i. kg^{-1}, Du Pont), and triasulfuron (as Logran 714 g a.i. kg^{-1}, Ciba-Geigy) were determined in a soil-free system as described by Jettner *et al.* (1993). It consisted of a two pot system; the crop grew in sand in the smaller pot, which was supported above and connected by a cotton wick with the hydroponic nutrient and herbicide solution in the larger pot. The use of this system eliminates the confounding effects of herbicide adsorption onto the soil particles, and will allow for the extrapolation of the results to any soil type.

Six glasshouse experiments were conducted, with separate experiments undertaken for each herbicide combined with four summer or winter crop species. The experiments involving metsulfuron methyl and triasulfuron included additional treatments with either sorghum (summer experiment) or chickpea (winter experiment) growing in chlorsulfuron residues. This enabled the results to be compared across experiments. Ten or eleven herbicide rates were used, which were replicated six times. The rates were selected from the rates 0, 0.05, 0.1, 0.25, 0.5, 1, 2.5, 5, 10, 50, 100, 500, 1000 µg a.i. L^{-1} of nutrient solution, and were selected on the basis of probable crop tolerance to each herbicide.

Herbicide injury symptoms, plant heights, fresh and dry weights of the shoots were recorded at either 21 (summer crops) or 28 (winter crops) days after sowing. A logistic equation was fitted to the data as a function of herbicide concentration by non-linear regression using Graphpad 3.1 statistical package:

$$Y = A + [(B - A)/(1 + (10^C/10^X)^D)]$$

where Y is shoot fresh weight (% of control) and X is the

Table 1. Concentration (µg L^{-1}) of chlorsulfuron, metsulfuron methyl and triasulfuron that induced 10, 30 and 50% inhibition of seedling growth (ID_{10}, ID_{30}, ID_{50}) of four summer crops. The 95% confidence limits for ID_{50} are in brackets.

Herbicide	Crop	Cultivar	ID_{10}	ID_{30}	ID_{50}
Chlorsulfuron	Cotton	Siokra L22	0.23	0.51	0.85 (0.68–1.08)
	Mungbean	Shantung	0.66	0.83	0.96 (0.65–1.42)
	Sorghum	Pacific 810	0.25	0.53	0.84 (0.71–1.01)
		Success 35	0.10	0.30	0.60 (0.51–0.71)
	Sunflower	Hysun 25	0.13	0.28	0.46 (0.35–0.59)
Metsulfuron methyl	Cotton	Siokra L22	0.11	0.29	0.52 (0.43–0.62)
	Mungbean	Shantung	0.18	0.39	0.63 (0.49–0.81)
	Sorghum	Success 35	0.42	0.61	0.77 (0.68–0.87)
	Sunflower	Suncross 41	0.03	0.07	0.14 (0.11–0.17)
Triasulfuron	Cotton	Siokra L22	0.50	0.78	1.04 (0.85–1.28)
	Mungbean	Emerald	0.10	0.26	0.48 (0.36–0.63)
	Sorghum	Success 35	0.40	0.86	1.40 (0.82–2.37)
	Sunflower	Suncross 41	0.17	0.24	0.29 (0.28–0.31)

herbicide concentration (µg L^{-1}). A and B denote the upper and lower asymptote, C is log (ID_{50}), the concentration of 50% seedling growth inhibition and D the slope at ID_{50}. The logistic equation was also used to derive ID_{10} and ID_{30} values, the herbicides concentration that inhibits 10% and 30% seedling growth.

RESULTS

General symptoms Stunting and poor, slow emergence were evident in all crops, except wheat and barley, when exposed to concentrations greater than 100 µg L^{-1} for all herbicides. Other injury symptoms were cessation of growth follow by chlorosis or sometimes an anthocyanin coloration of the lower leaves, necrosis and plant death.

Responses of summer crops The relative tolerance of the four summer crops varied with the herbicide, although sunflower was the most sensitive crop to all sulfonylureas (Table 1). The ID_{10} values for sunflower were less than 0.2 µg L^{-1}. Mungbean was the most tolerant to chlorsulfuron, whereas sorghum was the most tolerant to metsulfuron methyl and triasulfuron. The sorghum cultivars Pacific 810 and Success 35 were slightly different in their sensitivity to chlorsulfuron, although these responses were measured in different experiments (Success 35 was included in the triasulfuron experiment).

Responses of winter crops Wheat and barley were, as expected, very tolerant to residues of chlorsulfuron and triasulfuron (Table 2). The ID_{50} values for the winter cereals were 15–94 times greater than for canola and chickpea. Canola was more tolerant to chlorsulfuron residues than chickpea, but canola was more sensitive than chickpea for the other sulfonylureas. The chickpea cultivars were slightly different in their sensitivity to chlorsulfuron, although these responses were measured in different experiments.

DISCUSSION

The ID_{10}, ID_{30}, and ID_{50} values in these tables indicate the maximum sulfonylurea concentrations in solution that will cause no response, slight and moderate damage respectively (Pestemer *et al.* 1980). These may be used to predict when it safe to sown in the field or when there is a slight or significant risk of crop damage.

In the north-eastern grain region, the major crops grown in rotation with wheat and barley, in which the sulfonylureas are used, are chickpea and canola in winter and sorghum, sunflower, cotton and mungbean in summer. The data presented here indicate that the range of sulfonylurea concentrations that may cause slight or less damage to these crops is quite narrow. The ID_{30} values varied only from 0.24 to 0.86 µg L^{-1}, with the exception of sunflower and chickpea with metsulfuron methyl and canola with chlorsulfuron. Also, the range of concentrations causing none to moderate damage to each crop is narrow, indicating that measurements of these residues will need to be very accurate to make safe predictions. Crop cultivars appear to differ slightly in their sensitivity to sulfonylurea residues as shown here with sorghum and with maize (Churchett unpublished data).

The sorghum and chickpea responses to chlorsulfuron residues reported in this paper are similar to other results within Australia. However, the sunflower response to metsulfuron methyl residues was much

Table 2. Concentration (µg L^{-1}) of chlorsulfuron, metsulfuron methyl and triasulfuron that induced 10, 30 and 50% inhibition of seedling growth (ID_{10}, ID_{30}, ID_{50}) of four winter crops. The 95% confidence limits for ID_{50} are in brackets.

Herbicide	Crop	Cultivar	ID_{10}	ID_{30}	ID_{50}
Chlorsulfuron	Barley	Tallon	5.94	16.10	30.20 (16.2–54.9)
	Canola	Hyola 42	0.94	1.47	1.95 (1.24–3.07)
	Chickpea	Barwon	0.16	0.49	1.01 (0.68–1.49)
		Amethyst	0.14	0.83	2.54 (1.09–5.94)
	Wheat	Hartog	4.21	18.90	48.70 (3.08–758)
Metsulfuron methyl	Barley	Tallon	2.58	4.21	5.73 (4.07–8.06)
	Canola	Hyola 42	0.55	0.74	0.89 (0.71–1.10)
	Chickpea	Amethyst	0.69	1.95	3.73 (1.65–8.42)
	Wheat	Pelsart	1.41	3.77	6.99 (4.76–10.3)
Triasulfuron	Barley	Tallon	14.60	26.40	38.20 (0.51–2810)
	Canola	Hyola 42	0.28	0.45	0.59 (0.42–0.85)
	Chickpea	Amethyst	0.15	0.56	1.27 (0.66–2.45)
	Wheat	Pelsart	11.50	30.30	55.70 (9.58–323)

greater than found in an European study (Ferris and Haigh 1992).

In addition to this report, sensitivity data has been obtained for 30 crop species or cultivars to chlorsulfuron, which will be published shortly. Further work is currently being undertaken using this system to evaluated crop sensitivity to imazethapyr. The crop sensitivity data are being used to evaluate the results of field experiments, which are being grown under a range of seasons and soils for the prediction of safety of re-cropping (Walker *et al.* in press).

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