CROP SENSITIVITY TO RESIDUES OF ATRAZINE AND CHLORSULFURON IN A SOIL-FREE SYSTEM

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Summary. Although reduced crop growth resulting from residues of herbicides has been well documented, little is known about the levels of herbicide residues that cause crop damage. A soil-free system was used to study the growth response of the five main summer crops of south-east Queensland, sorghum (*Sorghum bicolor*), maize (*Zea mays*), sunflower (*Helianthus annuus*), cotton (*Gossypium sp.*), and soybean (*Glycine max*), to atrazine and chlorsulfuron. Crop sensitivity to atrazine and chlorsulfuron is measured in a soil-free system, eliminating the confounding effect of soil adsorption thus allowing for extrapolation to different soil types. Sunflower was the crop most sensitive to atrazine, with 0.01 mg ai/L reducing seedling growth by 10%. Soybean was the most sensitive crop to chlorsulfuron, tolerating only 0.08 µg ai/L chlorsulfuron. Results from the soil-free system will be validated under field conditions for prediction of safe recropping intervals.

INTRODUCTION

In the northern grain belt of Australia, farming practices are changing in recognition of the value of conservation cropping aimed at reducing soil erosion and maximising water infiltration and soil water storage. This has resulted in increased use of herbicides as the primary means of weed control and a reduction in tillage practices. The herbicides atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) and chlorsulfuron {2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) amino] carbonyl] benzenesulfonamide} obtain effective residual broadleaf weed control both in crop and into the fallow. The widespread adoption of residual herbicides is limited, however, by the variation in their persistence in different environments. This results in over-conservative recropping intervals in some situations or excessive carry-over causing injury to following sensitive crops (1).

Before recropping intervals can be predicted for different environments, the sensitivity of different crops needs to be determined and the level of herbicide in the root zone measured or predicted. The response of five summer crops to a range of atrazine and chlorsulfuron concentrations is measured using a soil-free system. This system eliminates the confounding effect of soil adsorption, and thus, allows extrapolation to different soils.

METHODS

Five summer crops were grown in a soil-free system with ten rates of either chlorsulfuron or atrazine in two experiments. The crop species studied included sorghum cv. Pac 810, cotton cv. Siokra L22, soybean cv. Manark, sunflower cv. Hysun 24, and maize cv. GH5010. Each experiment was a completly randomised block design with six replications. Similar techniques were used in both experiments.

The soil-free system was a two pot bioassay system modified from the hydroponic bioassay described by Stalder and Pestemer (4). A 150x140 mm diam. lined pot held the nutrient and herbicide solution and a 100x95 mm diam. lined pot with a layer of 20 mm basalt pebbles and filled with sterilised sand used to support the plant. A 120 mm pot saucer, with a 75 mm diameter centre piece removed, was placed on top of the larger pot as the lid with the 100 mm pot placed inside the saucer. A 150 mm cotton wick was used to draw up the solution culture from the lower to the top pot.

Five seeds each of the crop species were sown into the sand in 100 mm pots. Ten atrazine dose levels (0, 0.005, 0.01, 0.025, 0.05, 0.1, 0.25, 0.5, 1, 10 mg a.i./L) or ten chlorsulfuron dose levels (0, 0.1, 0.5, 1, 2.5, 5, 10, 50, 100, 500 μg a.i./L) were added to 1 L of commercial hydroponic nutrient solution (Manutec hydroponic nutrients®) and adjusted to pH 6.5. Nutrient solutions were replenished twice weekly with fresh solutions containing the same constitution.

At 7 d after sowing (DAS), plants were thinned to one plant per pot and algaecide (Howes Olympic®) applied. At 21 DAS, plant height and herbicide injury symptoms were recorded, plants were harvested, and fresh and dry weight of shoot growth was determined. Crops were grown under glasshouse conditions with the average day and night temperature of 16°C and 31°C.

A logistic equation was fitted to the data as a function of herbicide concentration by non-linear regression using Graphpad 3.1 statistical package:

$$Y = A + \left[\frac{B - A}{1 + (10^C/10^X)^D} \right]$$

where Y is shoot fresh weight (% of control) and X is the herbicide concentration (mg atrazine/L; μg chlorsulfuron/L). 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 herbicide concentration that inhibits 10% and 30% seedling growth.

RESULTS AND DISCUSSION

Response to atrazine. Shoot fresh weight response to atrazine differed significantly between the five crops (Fig. 1). The sequence of increasing crop tolerance was sunflower < cotton = soybean < sorghum < maize. There was a 15-fold difference in the concentration of atrazine required for 30% inhibition of fresh shoot growth between sunflower and sorghum (Table 1). This difference was even greater between sunflower and maize (Fig. 1). At 0.25 mg/L, sunflower seedlings were killed and cotton and soybean severely injured. Although atrazine is registered for use in both sorghum and maize, sorghum shoot growth was also reduced at 0.25 mg/L but maize shoot growth was only affected at concentrations greater than 1 mg/L. Our ID_{50} values for sunflower and soybean are similar to values measured by Pestemer *et al.* (3) also using a hydroponic system but different cultivars.

Plant stunting was visible 7 DAS. Chlorosis of oldest-leaf tip margins was evident on sunflower, cotton, and soybean 5 d later, followed by necrosis developing and plant death in the higher concentration treatments. Maize developed interveinal chlorosis, stunting, and lacked vigour in the 10 mg/L treatment 14 DAS.

Table 1. ID_{10}, ID_{30}, and ID_{50} values of cotton, maize, sorghum, soybean, and sunflower for atrazine and chlorsulfuron.

Crop	Atrazine (mg/L)			Chlorsulfuron (μg/L)		
	ID_{10}[a]	ID_{30}[b]	ID_{50}[c]	ID_{10}	ID_{30}	ID_{50}
Cotton	0.08	013	0.16	0.23	0.51	0.85
Maize	-	-	-	0.14	0.28	0.43
Sorghum	0.10	0.32	0.67	0.25	0.53	0.84
Soybean	0.08	0.12	0.16	0.08	0.21	0.39
Sunflower	0.01	0.02	0.04	0.13	0.28	0.46

[a]ID_{10}=Herbicide concentration that inhibits shoot growth by 10%
[b]ID_{30}=Herbicide concentration that inhibits shoot growth by 30%
[c]ID_{50}=Herbicide concentration that inhibits shoot growth by 50%

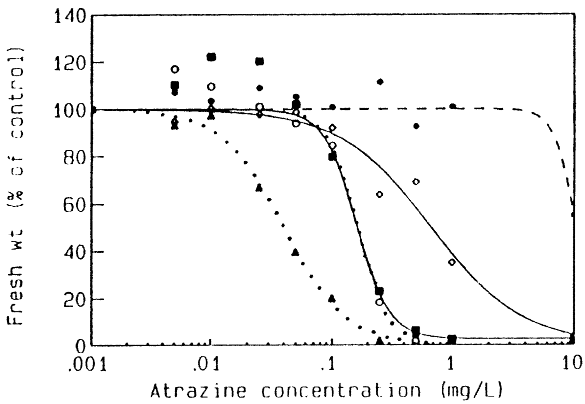

Figure 1. Relative fresh shoot weight of cotton (o ... o), maize (*--*), sorghum (◊—◊), soybean (■—■), and sunflower (▲ ... ▲) to atrazine concentrations in a soil-free system.

<u>Response to chlorsulfuron</u>. The difference in seedling response to chlorsulfuron between the crops (Fig. 2) was less than atrazine with only a two fold difference in ID_{30} between soybean and cotton or sorghum (Table 1). All species were highly sensitive resulting in a dramatic plant response over a narrow concentration range. The order of decreased sensitivity was soybean < maize = sunflower < sorghum = cotton. Our results for sorghum are similar to values measured by Haigh and Ferris (2) using the same system.

Treatment differences were evident 7 DAS with stunting and poor emergence of all crops at higher concentrations. Shoot growth ceased followed by chlorosis, terminal spikelet death, necrosis, and plant death. A purple to rust colour appeared on the base of the leaf of sorghum, sunflower, and soybean.

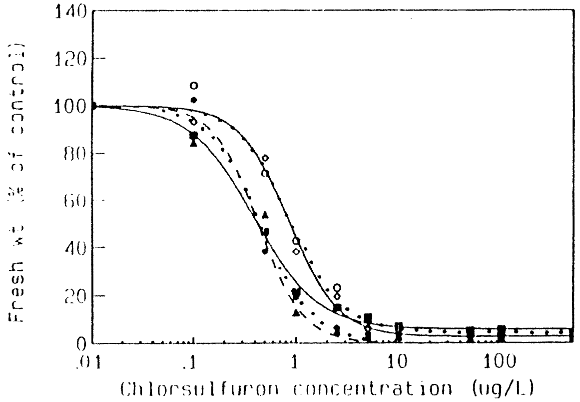

Figure 2. Relative fresh shoot weight (% of control) of cotton (o ... o), maize (*--*), sorghum (◊—◊), soybean (■—■) and sunflower (▲ ... ▲) to chlorsulfuron concentrations in a soil-free system.

Implications. For the measured crop sensitivity (ID values) to atrazine and chlorsulfuron to be of use for predicting crop response in the field, the plant available residue level in the root zone at planting needs to be measured or predicted. The investigation by Walker *et al.* (5) of the influence of soil factors on persistence, movement, and activity of atrazine and chlorsulfuron will greatly assist in predicting herbicide residues at planting.

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REFERENCES

1. Ferris, I.G. and Haigh, B.M. 1992. Proc. 1st International Weed Control Congress, Melbourne. pp 193-207.
2. Haigh, B.M. and Ferris, I.G. 1991. In: Modelling the Fate of Chemicals in the Environment (Ed. I. Moore) Australian National University Press, Canberra, ACT, pp 50-60.
3. Pestemer, W., Ghinea, L. and Radulescu, V. 1984. Residualwirkung von Chlortriazin-Herbiziden im Boden an drei rumanischen Standorten. II. Prognose moglicher Folgekulturen bei Atrazinruckstanden im Boden. Weed Research 24, 371-377.
4. Stalder, L. and Pestemer, W. 1980. Weed Research 20, 341-347.
5. Walker, S.R., Hargreaves, P.A., Jettner, R.J., Noble, R.M., Marley, J.M. and Osten, V.A. 1993. Proc. 10th Aust/14th APWSS Weeds Conf., Brisbane *in press*.