WHEAT AND CHICKPEA RESPONSE TO SUMMER APPLIED HERBICIDES IN CENTRAL AND SOUTHERN QUEENSLAND

J.E. Barnes[A], S.R. Walker[B], T. Dunmall[B], V.A. Osten[C], P.A. Hargreaves[D], R.M. Noble[E] and J.D. Churchett[B]
[A] Queensland Department of Primary Industries, PO Box 23, Kingaroy, Queensland 4610, Australia
[B] Queensland Wheat Research Institute, PO Box 2282, Toowoomba, Queensland 4350, Australia
[C] Queensland Department of Primary Industries, Locked Mail Bag 6, Emerald, Queensland 4720, Australia
[D] Resource Management Institute, 80 Meiers Road, Indooroopilly, Brisbane, Queensland 4068, Australia
[E] Queensland Department of Natural Resources, PO Box 201, Biloela, Queensland 4715, Australia

Summary Residual herbicides, while playing a major role in controlling weeds in our farming systems, can restrict the choice and time of sowing of subsequent crops. There was a need to reassess these herbicides to see if flexibility could be increased for the different soils and climates of central and southern Queensland. Atrazine (2 kg a.i. ha^{-1}) was applied to seven sites (pH 5.5–9), and flumetsulam (20 g a.i. ha^{-1}), imazethapyr (72 g a.i. ha^{-1}), and imazameth (48 g a.i. ha^{-1}) were applied to three sites (pH 5.5-7.8). Wheat and chickpeas were sown at 4–7 months after spraying either in intact soil cores, which were collected from sprayed sites and placed in the glasshouse, or in the field. Responses were measured by seedling biomass at four weeks after emergence at all sites, and crop yields at three field sites. Seedling biomass of wheat decreased with increasing pH, particularly in soils with pH greater than 8.1. At one site (pH 8.6) wheat seedling biomass was reduced to 37% of the untreated control plot. This was consistent with the available atrazine levels (0–10 cm) measured at planting, which increased with soil pH to 0.04 mg kg^{-1} at the site with pH 8.6. Chickpea seedling growth was not adversely affected at any site. This is consistent with the crop sensitivity data that showed that chickpea was less sensitive to atrazine residues than wheat. Residues of flumetsulam, imazameth and imazethapyr did not result in any seedling biomass or yield reductions (>10%) at any site. These results indicate that scope exists for modification of the re-cropping intervals for these herbicides for the different soils and climates of this cropping region.

INTRODUCTION

The farming systems of central and southern Queensland involve both summer and winter cropping. In summer, the main cereal crops are sorghum and maize, and the main grain legumes are mungbean, soybean, navy bean and peanut. They are planted from mid-December to the end of February in central Queensland and from early November to mid-January in southern Queensland. Wheat is the predominant winter crop in both regions, but barley and chickpea are also grown over large areas in southern Queensland. These crops are planted from mid-April to mid-June in central Queensland and mid-May to mid-July in southern Queensland.

Soils vary from alkaline black earths and grey clays to acidic kraznozems. Climate of this area is characterized by cool winters, including frost, and hot summers. Rainfall is summer predominant in all areas, but winter rainfall is more reliable in the Darling and western Downs than in the Burnett or central Queensland.

Atrazine is used extensively in the summer cereals. Current recommended recropping intervals for wheat and chickpea are six months for rates less than 1.1 kg a.i. ha^{-1}, and 18 months for higher rates irrespective of soil type. Imazethapyr is used in peanut, mungbean, and soybean, and the current plant-back period under dryland conditions is 15 months for wheat. Flumetsulam is registered in wheat but is also proposed to be used in soybean and peanut with a three month recropping interval for chickpea. Imazameth is to be registered as a fallow spray with a four month recropping interval for wheat and chickpea.

Farmer experience with atrazine has shown that in some cases recropping intervals are too conservative and in some cases too short and cause crop damage. Observations with imazethapyr have shown in some cases label recropping intervals are too long.

Persistent enquiries have indicated a need to assess whether the current recropping intervals can be adjusted for various soil types and climatic conditions of these regions. Also, there is a need to assess more widely, the newer herbicides.

This paper reports on results for the first year of experiments designed to investigate recropping of wheat and chickpeas into soils treated with these four herbicides in different environments.

MATERIALS AND METHODS

Atrazine (2 kg a.i. ha^{-1}) was applied to seven sites (Table 1). These sites covered the major soils of the cropping regions of Darling Downs, Burnett, and central Queensland. Soil pH ranged from 5.5 to 9. Flumetsulam (20 g a.i. ha^{-1}), imazethapyr (72 g a.i. ha^{-1}) and imazameth (48 g a.i. ha^{-1}) were applied to three sites with pH of 5.5-7.8 (Table 3).

Soil samples (0–10 cm) were taken at application and planting, and analysed for total and water-extractable (plant available) atrazine. Wheat and chickpea were planted in the three field sites (Table 2) treated with four herbicides at 4–7 months after application. At the remaining four sites, intact soil cores were taken from the atrazine treated and untreated plots, placed in a glasshouse and sown to wheat and chickpea.

Seedling biomass was measured at four weeks after crop emergence at the three field sites and from the intact soil cores. Yields were also measured at the three field sites at crop maturity. Rainfall from spraying to planting varied from 219 to 415 mm.

RESULTS

Wheat seedling biomass in atrazine treated plots decreased with increasing soil pH except for Jondaryan site (Table 2). Chickpeas were unaffected by atrazine residues at any site.

The percentage of total applied atrazine that remained at planting increased with soil pH, from 5% at pH 7.8 to 30% at pH 9. Water-extractable atrazine ranged from being not detectable (<0.002 mg kg^{-1}) to 0.03 and 0.04 mg/kg in the alkaline sites (Table 1).

At Kingaroy and Emerald field sites, wheat seedling responses ranged from 72 to 102% of the untreated for imazethapyr, 83 to 109% for imazameth, and flumetsulam at Kingaroy ranged from 92 to 144% of the untreated.

Yields of wheat and chickpeas were not affected by any of the four herbicides except at Emerald where atrazine and imazameth significantly reduced the yield of chickpea (Table 3). However these yield reductions (10 and 12% respectively) were not evident at double these rates.

DISCUSSION

After a summer application of these herbicides to soils with pH 8 or less, our preliminary data indicate that wheat can be safely sown in the following winter. Some caution with atrazine and imazameth is necessary on some soils with chickpea. It seems, therefore, possible to shorten the current recommended recropping intervals of 18 and 15 months for atrazine and imazethapyr respectively for some soils. Also, the current recropping interval of 3–4 months for flumetsulam seems appropriate.

Atrazine persistence increased with soil pH, which is consistent with that found by Walker *et al.* (1993) for similar Queensland soils. Atrazine half life varied from 23 to 150 days, and 89% of this variation was due to differences in soil pH and clay content.

Chickpea was more tolerant to atrazine than wheat except at Emerald. This agrees with the sensitivities of

Table 1. Site descriptions, measured water-extractable atrazine (WEA) residues (0–10 cm) at sowing, and recropping interval.

	Kingaroy 1	Kingaroy 2	Emerald	Dalby	Condamine	Toowoomba	Jondaryan
Soil							
pH	5.5	6.0	7.8	7.8	8.1	8.6	9.0
Clay (%)	56	56	69	63	39	71	72
WEA (mg kg^{-1})	<0.002	<0.002	<0.002	<0.002	0.01	0.04	0.03
Recropping interval (days)[A]	122	139	150	216	217	200	200

[A] Days from spraying to planting the subsequent crop.

Table 2. Wheat and chickpea shoot dry matter (SDM) g per plant (% of untreated).

	Kingaroy 1	Kingaroy 2	Emerald	Dalby	Condamine	Toowoomba	Jondaryan
Wheat SDM							
Treated	0.18 (101)	0.23 (111)	0.10 (77)	0.07 (114)	0.07 (67)	0.05 (37)[A]	0.05 (109)
Untreated	0.17	0.20	0.13	0.06	0.10	0.13	0.04
SE	0.11	0.14	0.01	0.01	0.01	0.01	0.01
Chickpea SDM							
Treated	0.20 (131)	0.16 (82)	0.32 (159)	0.13 (106)	0.14 (97)	0.14 (93)	0.09 (88)
Untreated	0.15	0.19	0.20	0.14	0.14	0.15	0.11
SE	0.12	0.16	0.002	0.02	0.01	0.01	0.01

[A] Denotes significant difference from the untreated plot (P=0.05).

Table 3. Yield (t ha^{-1}) of wheat and chickpea sown 4–6 months after application of atrazine, flumetsulam, imazethapyr, and imazameth.

	Kingaroy 1		Kingaroy 2		Emerald	
	Wheat	Chickpea	Wheat	Chickpea	Wheat	Chickpea
Atrazine 2 kg a.i. ha^{-1}	2.61	0.825	2.19	0.63	3.42	2.19[A]
Flumetsulam 20 g a.i. ha^{-1}	2.63	0.839	2.29	0.77	–	–
Imazethapyr 72 g a.i. ha^{-1}	2.75	0.888	2.16	0.99	3.34	2.42
Imazameth 48 g a.i. ha^{-1}	2.64	0.922	2.15	0.74	3.45	2.14[A]
Untreated	2.75	0.771	2.15	0.79	3.43	2.42
Standard error	0.11	0.09	0.14	0.14	0.10	0.04

[A] Denotes significant difference from the untreated plot (P=0.05).

the two crops, which were determined in a soil free system (Jettner personal communication). The atrazine doses that inhibited 50% of the seedling growth (ID_{50}) were 0.07 and 0.26 mg L^{-1} for wheat and chickpea respectively.

The differences in wheat seedling response between sites were related to the concentrations of water-extractable atrazine in the root zone at sowing. The crop was not adversely affected when the water-extractable atrazine was less than 0.04 mg kg^{-1}. This critical value could be useful for predicting crop response with herbicide persistence models outlined by Ferris and Haigh (1992).

The data presented here is only for one year, and this research will be repeated over different seasons. Differences in seasonal rainfall is likely to influence recropping intervals of these herbicides. Haigh and Ferris (1991) showed that atrazine degradation increased with soil water content. The other three herbicides are degraded by soil microbes and rate of degradation is likely to increase with soil water content.

It is hoped that a decision support package can be produced at the end of this project. The fixed recropping intervals may be replaced with prescription recommendations adjusted for differences in soils, climate and crops as suggested by Ferris and Haigh (1992).

ACKNOWLEDGMENTS

The authors wish to thank the Grains Research and Development Corporation for funding this project, and the staff at the various centres who assisted in this project.

REFERENCES

Ferris, I.G. and Haigh, B.M. (1992). Prediction of herbicide persistence and phytotoxicity of residues. Proceedings of the First International Weed Control Conference, Melbourne, p. 193.

Haigh, B.M. and Ferris, I.G. (1991). Predicting herbicide persistence using the CALF model. *In* ‘Modelling the Fate of Chemicals in the Environment’, ed. I. Moore, Australian National University Press, Canberra, ACT, pp. 50-60.

Walker, S.R., Hargreaves, P.A., Jettner, R.J., Noble, R.M., Marley, J.M. and Osten, V.A. (1993). Towards safer and more efficient use of residual herbicides in the north-eastern grain region of Australia. Proceedings 10th Australian and 14th Asian-Pacific Weed Conference, Brisbane, p. 198.