Imazethapyr Recropping Recommendations for Canola are Suitable for Australia's Neutral-Alkaline Soils.

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ABSTRACT

Imazethapyr is a residual imidazolinone herbicide used to control weeds in pulse crops. Although used extensively in Australia, leaching and persistence of the herbicide in these soils has not been studied. We applied imazethapyr to a neutral - alkaline sodic soil in the Victorian Wimmera to separate plots in 1996, 1997 or 1998 and sampled the soil for residues. In 1999 canola (*Brassica napus* L.), a species highly susceptible to imazethapyr residues, was sown to assay for phytotoxic activity of residual herbicide. Canola sown three years after imazethapyr application yielded well but the canola sown after one or two years suffered stunting or yield loss. Imazethapyr residues persisted mainly in the top 10 cm of the poorly drained sodic soil. The processes leading to imazethapyr degradation in Australian neutral-alkaline soils require further investigation.

KEY WORDS

Imazethapyr, imidazolinone, herbicide, residue, recropping, alkaline.

INTRODUCTION

Imazethapyr is a pre-emergent residual imidazolinone herbicide used for controlling selected broadleaf and grass weeds in pulse crops. Imidazolinone use is likely to increase with the popularity of pulses and the introduction of imidazolinone-tolerant canola. Like the sulfonylurea herbicides imazethapyr is a Group B, ALS inhibitor herbicide but it has a different chemistry. Unlike the sulfonylureas, imazethapyr is likely to persist longer in acid than in alkaline soils(7).

There have been no published studies of the soil residual activity of these herbicides under Australian conditions and few on alkaline soils. A Canadian study (7) found a general trend towards reduced persistence of imazethapyr with higher pH but only included soils up to pH 7.0. Imazethapyr leached below 25 cm in four months in lab studies with acid soil (4) and has been detected in stream and river water in Midwestern US at concentrations above maximum residue limits in 71% of samples (1). Another imidazolinone herbicide, imazapyr, was highly persistent over 12 months in alkaline soil (pH 8.1) in Texas with minimal leaching (2).

Imazethapyr is the main imidazolinone herbicide used in the Victorian cropping industry. The Australian label for imazethapyr (Cyanamid Spinnaker?) recommends a 34 month recropping interval for canola regardless of soil pH. Therefore, the potential for damage to canola crops needs to be investigated in south eastern Australia's neutral to alkaline soils. The aim of this study was to quantify imazethapyr leaching and persistence in Victorian soils and to assess the impact of any residues on canola crops grown in subsequent seasons.

MATERIALS AND METHODS

Field trials The field trials were located in the Victorian Wimmera at Kaniva on a sodic clay soil, pH_{water} 6.3-8.2 and organic matter 3.1% in the top 10 cm. Four replicates of each herbicide treatment and a control were arranged in a randomised block design with plots 4 x 20 m.

Imazethapyr (300 ml/ha Cyanamid Spinnaker? pre-emergent) was applied in 1996, 1997 and 1998 to separate plots using a motorbike sprayer in 64 L/ha water. Plots treated with imazethapyr were sown with peas (*Pisum sativum* L cv. Dun) at 100 kg/ha in the year of application and cereals in other years. In 1999

canola (cv. Dunkeld) was sown at 5 kg/ha across the sites and emergence, dry matter and grain yield were measured and analysed by ANOVA. Visual ratings using the European Weed Research Council (EWRC) system of 1 (no effect) to 9 (total loss of plant) were made in August. Cumulative temperature was calculated by adding the daily minimum and maximum temperatures for the defined time period (10).

Soil samples for residue determination were taken pre-sowing, mid-season and at harvest with a hydraulic sampler using a 10 cm diameter split core to a depth of 40 cm and separated into 0-10, 10-20 and 20-40 cm depths. Samples were refrigerated at 4?C within a day of sampling and then dried at 40?C for 18 h for long term storage at 4?C. They were crushed to 2 mm and homogenised prior to bioassay analysis.

Bioassays Canola (cv. Rainbow) root length reduction bioassays were used to estimate the herbicide concentration in soil samples collected from the field. The assays were grown for 7 days in a controlled environment room with a 21/11?C day/night temperature and 12 hour day length.

Control soil from the same site was dosed in the laboratory with a range of imazethapyr concentrations to prepare calibration curves of herbicide concentration related to root length reduction for each depth of soil. This ensured that any interaction between the herbicide and soil characteristics, such as sodicity, were accounted for. Non-linear regression analysis was used to fit these calibration curves to a logistic dose response curve model (8). Concentrations less than the effective dose required to give 10% root length reduction (ED_{10}), calculated from the calibration curve, were considered not significant as were any concentrations not significantly different from control soil assayed simultaneously.

RESULTS

Imazethapyr residues were detected in the soil more than three years after application (Table 1). Generally leaching was minimal but more imazethapyr moved beyond 10 cm in 1996 that was the wettest year with 311 mm of rainfall during the 133 days between application and sampling. There was less leaching in the two dry years of 1997 and 1998 which had only 80?mm rainfall in 86 days and 98 mm in 84 days respectively.

Table 1. Imazethapyr (ng a.i./g dry soil) residues at Kaniva for each sampled depth. The application rate of 300 ml product is equivalent to 42.4 ng a.i./g soil in the top 0-10 cm of the soil.

Sampling	**1996 application**				**1997 application**				**1998 application**			
date	DAT[1]	0-10 cm	10-20 cm	20-40 cm	DAT	0-10 cm	10-20 cm	20-40 cm	DAT	0-10 cm	10-20 cm	20-40 cm
22-Oct-96	133	7.66	5.27	3.10								
30-May-97	353	4.50	1.49	0.25								
26-Aug-97	441	5.35	2.31	0.33	86	15.58	2.15	0.11				
16-Dec-97	553	3.50	0.94	0.40	198	7.15	2.12	0.20				

13-May-98	701	2.33	0.98	0.33	346	6.65	0.84	ND				
18-Aug-98	798	2.47	1.12	0.14	443	5.92	1.43	ND	84	>29.4	3.48	0.50
3-Dec-98	905	3.46	0.72	ND[2]	550	3.57	1.03	0.26	191	15.58	1.63	0.28
18-May-99	1071	1.59	ND	ND	716	5.27	0.63	ND	357	12.11	2.60	ND
13-Sep-99	1189	3.27	0.93	ND	834	3.44	0.89	ND	475	5.85	2.21	ND

[1]DAT - Days after treatment. [2]ND - residue not detected

Canola sown three years after the 1996 application was visually similar to the control plots but reduced vigour was reflected in the EWRC rating of 3.5 compared to 1 for the control (Table 2). This crop compensated well and there was a slight but not statistically significant (p=0.05) reduction in dry matter and yield.

Table 2. Canola EWRC, dry matter (DM) and yield in 1999 on plots at Kaniva treated with imazethapyr in 1996, 1997 or 1998 with DM and grain yield expressed as a percentage of the control treatment. Statistically significant (p=0.05) results are marked with an asterisk.

Year of imazethapyr application	EWRC	DM (% of control)	yield (% of control)
1996	3.5	83	94
1997	6.0	*64	79
1998	9.0	*5	*0

Canola sown two years after the 1997 application had a yield reduction of 21% which was not significant (p=0.05) and was visibly stunted and thinner than the control plot. The stunting may have been because the plants were less vigorous and had less need to compete with their neighbours.

Canola sown one year after the 1998 application had only 5% of the dry matter of the control crop and there was no yield. The plots were bare except for a few very stunted plants.

Table 3. Rainfall totals (mm) before and after application of imazethapyr and daily rainfall for the first 14 days after application at Kaniva for 1997 and 1998.

Year	28 d total	7 d total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14 d total	21 d total	28 d total

	pre	**pre**															**post**	**post**	**post**
1997	43.0	23	0	0	0	0	0	2	2.8	0.2	0	0	0	4.2	4.4	1.6	15.2	15.4	18.2
1998	28.8	21.6	0	0	0	0	0	0	0	0	0.2	0.2	14.6	8.0	0	0	23.0	36.4	43.8

DISCUSSION

Recropping This study showed that the imazethapyr label recropping recommendations of 34 months for canola is suitable for the neutral - alkaline soils of Victoria. Canola sown three years after imazethapyr application showed no significant damage to the crop or loss of yield. In contrast canola sown one year after imazethapyr application did not yield at all.

The yield of canola sown two years after application was not significantly reduced but the crop had suffered stunting during the growing season. Obrigawitch *et al*. (6) also found that damage during the growing season does not always lead to a significant yield penalty. The label caution against recropping with canola two years after imazethapyr application probably reflects the potential vulnerability of the crop to other stresses in the presence of imazethapyr residues. Our next step is to evaluate grain size, germination and oil quality characteristics of harvested canola to ensure there are no other concerns.

Residues The bioassay detected imazethapyr residues in the soil profile throughout the 1999 canola growing season for all imazethapyr application dates. Yet, there was only significant yield reduction for canola sown one year after application. This shows that canola can overcome some imazethapyr residue in soil. In this neutral-alkaline soil the threshold value which caused yield loss in canola was between 5.90 and 14.71 ng a.i./g pre-sowing (May 1999). Imazethapyr concentrations of 5.90 ng a.i./g and below did not cause a significant yield reduction in canola.

Residues were mainly found in the top 0-10 cm soil fraction but some imazethapyr was found in the 10-20 cm and 20-40 cm depths. This minimal leaching may be due to the sodic nature of the soil at Kaniva that minimises water infiltration. Imazethapyr leached throughout the 40cm soil profile measured at Dooen where the clay soil is not as sodic (5). Rainfall was average following application in 1996 and we were prevented from soil sampling because of waterlogged soil. This is reflected in the movement of imazethapyr into the 10-20 cm and 20-40 cm depths in 1996. In the drier years of 1997 and 1998 only small amounts of imazethapyr were detected beyond the top 20 cm.

Residues detected in the first sampling in 1998 were almost double those found in 1997 despite the similar sampling time and rainfall between application and sampling. A comparison of the cumulative temperature for the same time interval showed very little difference between the years with 1432?C for 1997 and 1457?C for 1998 which means that 1998 was 0.7?C warmer per day than 1997. While cumulative temperature has proven to be a good indicator of break down and safe recropping in subtropical Australia (10) the difference at Kaniva is unlikely to be significant. Temperature does not offer an explanation for the almost twofold difference in residues.

Degradation of imazethapyr is enhanced as both temperature and soil water increase (3). Both 1997 and 1998 had similar soil water profiles before herbicide application. There was a slight difference in rainfall timing after application with the first rain in 1997 on day six, while it was day 11 before there was significant rainfall in 1998. The extended dry period may have been sufficient to allow better sorption of imazethapyr in 1998. Delays in rainfall have been shown to improve sorption of flumetsulam, another ALS herbicide, and reduce its susceptibility to leaching and break down (9). However, this does not take into account the relatively large rain event of 14.6?mm on day 11 in 1998 that may have desorbed imazethapyr making it available for break down or leaching.

CONCLUSIONS

These results indicate that the 34 month recropping recommendation is valid in this neutral-alkaline sodic clay. Canola is capable of yielding well despite some imazethapyr residue remaining in the soil profile.

The influence of temperature and rainfall on the rate of breakdown of imazethapyr are not clear and will need further evaluation with data from other Australian sites.

ACKNOWLEDGMENTS

Thanks to Peter Hicks for the use of his land, Russel Argall for managing the field trial, Roger Perris, Maree Kerr, David Puls, Gene Tagliabue and Michael Kalms for their technical support and Michael Moerkerk for EWRC measurements. This work was funded by the GRDC.

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