Metsulfuron-methyl residues and potential recropping damage in Victorian cropping soils.

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ABSTRACT

Leaching and persistence of the sulfonylurea herbicide metsulfuron-methyl was investigated in three neutral to alkaline soil types in the dryland cropping area of Victoria. The herbicide leached to a depth of 40 cm in mallee sand but usually remained in the top 10 or 20 cm of clay soils. The herbicide persisted for longer when applied in years of below average rainfall. Apart from medics there were no recropping problems one year after herbicide application with crops listed on the label as having a 9 month minimum recropping interval. There was often slight stunting and yellowing of crops but this did not affect grain yield. Of particular concern was 38% dry matter reduction in medic sown 10 months after herbicide application at one site with pH 8.5. Caution is needed when sowing medics on clay soils near the upper pH limit of label recommendations and in drier than normal years as damage may occur despite adherence to label recommendations.

KEY WORDS

Metsulfuron-methyl, sulfonylureas, group B herbicides, residues, sensitive crops.

INTRODUCTION

Metsulfuron-methyl is a sulfonylurea in herbicide group B. It is used alone or as a mixture to control broad leaf weeds in cereal crops. Much of the cropping area of south-eastern Australia has alkaline soils. The sulfonylurea herbicides breakdown through both microbial action and chemical hydrolysis. Soil pH has an influence on the rate of breakdown by hydrolysis. The greater the soil pH the less hydrolysis occurs, therefore the breakdown in alkaline soil is mostly through microbial activity (2). Also with increasing pH, the herbicide is more soluble hence able to leach from the relatively microbe rich topsoil to deeper in the profile where microbial breakdown is less likely to occur. The impact of these residues on crops sown in years following application is of concern as very low concentrations can cause crop damage. In this study metsulfuron-methyl residues in three soils were quantified and potential damage to sensitive crops was examined. The results were related to recropping recommendations on the product label.

MATERIALS and METHODS

Field trials: These were located at Kaniva (sodic clay, pH 6.3 to 8.2, organic matter (OM) 3.1%, average annual rainfall 450 mm), Dooen (cracking grey clay, pH 8.5, OM 2.7 %, av. annual rainfall 410 mm) and Walpeup (mallee sand, pH 7.4, OM 1.2%, av. annual rainfall of 340 mm). The pH (1:5 soil water suspension) and organic matter values quoted are for the top 10 cm of soil. All sites have a temperate climate with winter dominant rainfall.

Metsulfuron-methyl (7?g?ha^{-1} Dupont Ally$^{?}$, equivalent to 2.5 ng a.i. g soil^{-1} in the top 10 cm) was applied early post-emergence at all sites in 1996, 1997 and 1998 on separate plots using a motorbike sprayer at 64?L ha^{-1}. Four replications of each herbicide treatment and a control were arranged in a randomised block design with plots at least 3 x 20m. Cereal crops were sown on the plots in 1996, 1997 and 1998.

In 1999 plots were divided into thirds and three crops sensitive to sulfonylurea herbicides sown. Kaniva and Dooen sites were sown on 27/5/99 and 9/6/99 respectively with 5 kg ha^{-1} canola (*Brassica napus* L.) cv. Dunkeld, 5 kg?ha^{-1} medic (*Medicago truncatul*a J. Gaertn.) cv. Mogul and 54 kg ha^{-1} lentil *(Lens culinaris* L.) cv. Digger. The Walpeup site was sown on 7/6/99 with 5 kg ha^{-1} canola cv. Hyola 42, 5?kg?ha^{-1} medic cv. Caliph and 103 kg ha^{-1} peas (*Pisum sativum* L.) cv. Dundale. The medic was resown on 12/7/99 after severe insect damage to the initial sowing.

Crops were assessed for emergence, dry matter at flowering and overall visible damage using the European Weeds Research Council (EWRC) rating system where no effect rates 1 and total plant loss rates 9. Grain yield of canola, lentil and pea or medic burr (Dooen only) was taken from an area at least 16.2 m^2 at crop maturity. At Walpeup the only measurement taken of re-sown medic growth was the EWRC rating because this was later than the other crops and time constraints applied.

Residue analysis: From mid 1996 soil samples were taken pre-sowing, mid-season and at harvest of crops each year with a hydraulic sampler using a 10?cm diameter split core to a depth of 40?cm at Kaniva and Dooen, and 60?cm at Walpeup. These samples were divided into 0-10 cm, 10-20 cm, 20-40?cm and 40-60?cm sections of the soil profile. The samples were refrigerated within a day of collection, then dried at 40?C for 18 h before long term storage at 4?C. They were crushed to 2?mm maximum diameter and homogenised prior to laboratory bioassay analysis, based on root length reduction of lentil cv. Digger or pea cv. Dundale, to detect herbicide residues. This bioassay method is described by Stork (4), except in this case the soil was dried and crushed before re-wetting for the bioassay. Residues from the four replicate plots were determined separately then averaged. Soil sampling continued until residues were unable to be detected at two consecutive sampling dates.

Soil pH analysis: Further pH tests were taken at Dooen as initial tests gave an average pH of 8.5 that is borderline for certain recropping intervals. Four samples were taken to a depth of 10 cm on all control and metsulfuron-methyl plots, one each within canola and lentil plots and two within medic plot areas. These were analysed by the Victorian State Chemistry Laboratory.

Statistical analysis: Data on emergence, dry matter, and grain or burr yield was analysed with a single factor ANOVA to test whether herbicide residues affected crop performance.

RESULTS and DISCUSSION

Leaching and persistence of residues

In the poorly drained sodic Kaniva soil residues mostly remained in the top 10?cm of the soil (Table?1), while in the better drained Dooen clay residues were spread throughout the top 20?cm (Table?2). In the Walpeup sand residues leached further spreading through the top 40?cm (Table 3). This is consistent with the fact that metsulfuron-methyl is soluble in water in neutral to high pH soils and would be expected to move with rain water through the soil profile. This was found to occur in a laboratory leaching study where depth of sulfonylurea movement coincided with water movement in neutral soil with 1.4 % organic matter (1).

We found greater persistence of metsulfuron-methyl associated with low rainfall during the growing season. The 1996 season had average rainfall while 1997 was drier than normal and 1998 was the driest of the three seasons. Residues were detected in the subsoil at Kaniva 14.5 months after the 1998 application while in 1996 and 1997 no residues were found as early as 3 and 5 months after treatment (MAT) respectively. The Dooen site with its higher pH was more vulnerable to dry conditions with residues detected 13 and 9 MAT in 1997 and 1998 respectively but no residues just 2.5 MAT in 1996. In alkaline soils microbial degradation, particularly in the topsoil, is the main mode of breakdown of sulfonylurea herbicides. Our results show that regular rainfall is vital for this breakdown.

Metsulfuron-methyl residues were detected at greater concentrations at depth in the drier years than in 1996. It is generally understood that leaching is minimised in dry years yet these results appear to suggest the opposite. However, we believe the results show that reduced microbial degradation in the topsoil under dry conditions leads to greater concentration of herbicide available for leaching into the subsoil. Hence, the total profile residue concentration may be greater in dry years.

Table 1. Residues of metsulfuron-methyl to a depth of 40 cm at Kaniva at each soil sampling date showing months after treatment (MAT) and cumulative rainfall.

Application date	Sampling date	MAT	Cumulative rainfall (mm)	Residues (ng g dry soil^{-1}) at each depth 0-10 cm	10-20 cm	20-40 cm
23/7/96	22/10/96	3.0	196	0.0	0.0	0.0
21/7/97	26/8/97	1.0	51	0.5	0.0	0.0
	16/12/97	5.0	168	0.0	0.0	0.0
1/7/98	18/8/98	1.5	52	1.1	0.0	0.0
	3/12/98	5.0	217	0.3	0.0	0.0
	18/5/99	10.5	228	0.0	0.0	0.0
	13/9/99	14.5	304	0.0	0.2	0.2
	6/1/00	18.0	469	0.0	0.0	0.0

Residue results in Tables 1-3 show some variation, for example, the apparent reappearance of metsulfuron-methyl residues 14.5 MAT when the soil was clear at 10.5 MAT (Table 1). This apparent anomaly reflected the difficulty in detecting concentrations near the assay detection limits. Variation may also result from soil being sampled from different areas of the plot each time because of variation in leaching and degradation within plots. This reinforces the need to view the results as a broad trend rather than focus on exact concentrations at each sampling.

Table 2. Residues of metsulfuron-methyl to a depth of 40 cm at Dooen at each soil sampling date showing months after treatment (MAT) and cumulative rainfall.

Application date	Sampling date	MAT	Cumulative rainfall (mm)	Residues (ng g dry soil^{-1}) at each depth 0-10 cm	10-20 cm	20-40 cm
12/8/96	30/10/96	2.5	136	0.0	0.0	0.0

22/7/97	2/10/97	2.5	119	0.4	0.5	0.0
	11/12/97	4.5	189	0.3	0.3	0.0
	20/5/98	10.0	301	0.0	0.2	0.0
	25/8/98	13.0	411	0.0	0.3	0.0
	10/12/98	16.5	544	0.0	0.0	0.0
5/8/98	25/8/98	0.5	58	1.0	0.0	0.0
	10/12/98	4.0	191	0.4	0.2	0.0
	11/5/99	9.0	257	0.4	0.0	
	1/9/99	13.0	350	0.0	0.0	0.0

Table 3. Residues of metsulfuron-methyl to a depth of 60 cm at Walpeup at each soil sampling date showing months after treatment (MAT) and cumulative rainfall.

Application	Sampling	MAT	Cumulative	Residues (ng g dry soil^{-1}) at each depth			
date	date		rainfall (mm)	0-10 cm	10-20 cm	20-40 cm	40-60 cm
2/7/96	20/8/96	1.5	67	0.1	0.1	0.1	0.0
	15/10/96	3.5	147	0.0	0.0	0.0	0.0
	20/6/97	11.5	236	0.0	0.0	0.0	0.1*
	1/12/97	17.0	404	0.0	0.0	0.0	0.0
31/7/97	19/8/97	0.5	35	0.1	0.1	0.1	0.0
	1/12/97	4.0	155	0.0	0.0	0.0	0.0

15/6/98	11/8/98	2.0	41	0.1	0.0	0.0	0.0
	25/11/98	5.5	178	0.0	0.0	0.2	0.2
	1/6/99	11.5	323	0.0	0.0	0.0	0.0

*residue found in one replicate plot only.

Recropping trials

Kaniva: Visible damage to lentils and medics consisting of slight stunting and yellowing was seen in August 1999 after herbicide application in 1997 and 1998 (EWRC ratings 2 to 3 respectively). Soil sampled closest to this time, in September 1999, had residues from the 1998 application between 10 and 40?cm but residues from the 1997 application were not detected after late 1997. The crops were therefore susceptible to visible damage from residue levels not detected by the bioassay. Most importantly there was no decrease in emergence, dry matter or yield of any crops.

Dooen Damage occurred to sensitive crops sown in June 1999 (Table 4), 10 months after the 1998 application, despite exceeding the recommended recropping period of 9 months for Ally? (metsulfuron-methyl) on soils up to pH 8.5. Soil sampled in May 1999 prior to sowing showed herbicide residues from the 1998 application in the top 10?cm. However, no detectable residues were found in September 1999 (Table 2) when EWRC and dry matter measurements showed damage to sensitive crops (Table 4). The residues detected at sowing and possibly undetectable residues later in the season caused all crops to exhibit slight stunting and yellowing (EWRC rating 3) symptoms typical of sulfonylurea residue damage. There was no reduction in dry matter or yield of canola. Lentils showed significant dry matter and yield reduction, however, as a relatively new crop there are no label recropping recommendations for lentils.

Of greatest concern was the 38% reduction in dry matter of medics 4 months after sowing. As this is a pasture species dry matter is more important than burr harvest yield which was not reduced. To find if the pH in areas where medics were sown was possibly above 8.5 we did further tests. Soil pH of two samples from the medic area of each 1998 application were 8.2 and 8.2 for plot one, 8.4 and 8.5 for plot two, 8.5 and 8.4 for plot three, and 8.6 and 8.5 for plot four. The pH on these plots averaged 8.4. The average pH of all thirty two soil samples from control and metsulfuron-methyl plots was 8.5 ranging from 8.3 to 8.6.

In two previous experiments at a nearby Dooen site in 1994 and 1995 there was no reduction in dry matter of medics sown one and two years after the same application rate of metsulfuron-methyl, however at this site the pH averaged 8.0 (3).

Table 4. Dooen crop EWRC rating, dry matter (DM)(g m^{-2}) and yield (t?ha^{-1}).

Treatment	lentil EWRC	lentil DM	lentil yield	canola EWRC	canola DM	canola yield	medic EWRC	medic DM	medic yield
control	1	181.2	1.21	1	385.6	0.69	1	233.5	0.084
1998 herbicide application	3	123.7 [A]	0.66 [A]	3	317.0	0.73	3	144.2 [A]	0.077

LSD (P=0.05)	n/a	45.8	0.28	n/a	75.3	0.086	n/a	68.3	0.017

[A] Significant difference to control

There was no effect on EWRC rating, dry matter or grain yield of crops sown on plots with herbicide applied in 1996 or 1997 which had no detectable residues near sowing time.

Walpeup: There were no visible differences to the controls for medic and peas. There was very slight stunting and chlorosis (EWRC rating 2) of canola sown on 1996 and 1998 application plots but this also occurred on control plots. No residues were detected near sowing time. There was no decrease in emergence, dry matter, or final yield of peas and canola. No measurements other than EWRC ratings were taken for the medics.

CONCLUSION

Metsulfuron-methyl residues persist for a longer period after a dry year. In free draining sandy soils considerable loss of the herbicide from the top 10 cm of soil occurs through leaching, whereas in the clay soils studied residues tend to stay between 0 and 20?cm. In some instances metsulfuron methyl residues can cause visible damage to sensitive crops during the growing season but this does not necessarily lead to yield loss. Caution is needed in using metsulfuron-methyl on soils at a pH near the stated label limit where medics are planned for pasture next season as growth reduction may occur. In soils with a pH near the label limit both rainfall and soil structure are further factors that should be considered before sowing sensitive species such as medics.

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