INFLUENCE OF LIME ON ACTIVITY AND PERSISTENCE OF TRIBENURON AND THIFENSULFURON IN SOIL

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ABSTRACT

The effect of lime and burnt lime (CaO) on the activity and persistence of the herbicides tribenuron and thifensulfuron in three soils was investigated in glasshouse experiments. The activity of the herbicides was determined by bioassays using white mustard (*Sinapis alba*) and lentil (*Lens culinaris*) as test species. Applications of lime or burnt lime to soil before the herbicides were applied, significantly increased the activity and persistence of tribenuron, but not of thifensulfuron. Addition of water after application of lime or burnt lime sometimes diminished this effect. The application of lime and burnt lime increased the soil pH. Thus for tribenuron, a longer waiting period would be required before planting in situations where lime had recently been applied to the soil.

Keywords: tribenuron, thifensulfuron, soil pH, lime, conservation tillage

INTRODUCTION

Extensive field and laboratory studies have shown that the phytotoxicity and persistence of most sulfonylurea herbicides is influenced by soil characteristics, particularly pH (Beyer *et al.* 1987; Blair and Martin 1988; Brown 1990). Sulfonylureas are weak acids with a pKa of 3 to 5 and their rate of hydrolysis is pH dependent (Brown 1990; Hay 1990). Soil pH controls the rate of sulfonylurea bridge hydrolysis through its effect on ionisation, with faster hydrolysis occurring at acidic pH values. This response of hydrolysis to pH forms the basis for the soil pH guidelines governing the use of longer residual sulfonylureas.

The herbicide tribenuron is used in New Zealand as part of a combination treatment for control of certain weeds in conservation tillage situations. A waiting period of 14 days is suggested before planting the recommended crops (O'Connor 1996). In a study comparing the biological activity of tribenuron in soils from five major agricultural regions of New Zealand, James *et al.* (1989) reported that the herbicide was most active in a high pH (6.7) soil from Hastings and least active in a Hamilton soil with a low pH (5.3). Riise (1994) found that the extent of absorption of tribenuron increased with decreasing pH, especially in heavy textured soils. In soil, tribenuron usually undergoes rapid chemical hydrolysis, but the persistence is known to vary between soils (Brown 1990; Kotoula-Syka *et al.* 1993).

In conservation tillage systems lime applications are often made before sowing to ensure good soil conditions. Addition of lime and increasing soil pH may increase the persistence of tribenuron and result in injury to labelled crops planted after the recommended waiting period. The objective of this study, therefore, was to determine the effect of lime, with and without watering, on the activity and persistence of tribenuron in three soils. In addition to agricultural lime, burnt lime was included because of its greater water solubility and more rapid alteration of soil pH. The herbicide thifensulfuron was included as a comparison because it can potentially be used for weed control in conservation tillage situations and has little residual activity in New Zealand soils (Rahman and James 1991).

MATERIALS AND METHODS

This study included three soils: a Lismore silt loam (53% sand, 18% clay, 3.4% organic C, pH 5.5) from Canterbury, a Hamilton clay loam (36% sand, 26% clay, 2.8% organic C, pH 5.5) from Waikato, and a Horotiu sandy loam (61% sand, 16% clay, 7.3% organic C, pH 5.6) from Waikato. Bulk soil samples were collected from the top 10 cm of three arable sites and the individual samples were thoroughly mixed and passed through a 4 mm sieve before use.

The field moist soil was placed in 120 plastic trays (290 x 420 x 50 mm) and treated with either agricultural lime (CaCO_3) at a field rate of 2.5 t/ha (30.5 g/tray), burnt lime (CaO) at an equivalent rate of calcium (15 g/tray) or left untreated as a control. After the application of lime, the soil was stored at 10°C until bioassays were conducted.

The lime treatments were left undisturbed for 2 weeks at which time half the trays were watered by overhead irrigation. The Lismore silt loam soil received a total of 18 mm over a 3 day period, while the Hamilton clay loam and the Horotiu sandy loam soils received 13 mm and 15 mm respectively, over 2 days. In all cases the soil was close to field capacity after the watering. Soils were then left undisturbed for a further 2 weeks before tribenuron (Granstar 75% WDG) and thifensulfuron (Harmony 75% WDG) treatments were applied. The herbicide treatments were applied to the soil with a moving belt pot sprayer using a single TeeJet 8002E nozzle at 200 kPa to apply 300 litres/ha. After spraying the trays were left undisturbed for a further 3 days before the soil was transferred to polythene bags and thoroughly mixed and then stored until bioassayed.

Four replications of each of the two bioassay species (white mustard (*Sinapis alba*) and lentil (*Lens culinaris*)) for each treatment were planted, 7 and 14 days after the herbicides were applied. Approximately 15 seeds of each species were planted per pot and the pots were placed on a glasshouse bench in a randomised block design. The resulting seedlings were thinned to 10 per pot soon after emergence. The bioassay plants were maintained in the glasshouse under natural light with day temperatures of 20 - 30°C and night temperatures of 15 - 20°C. Pots were watered as required to maintain the soil moisture between 80 and 100% of field capacity. Visual observations of plant damage were made throughout the duration of the experiments and all foliage was harvested for dry matter yield determinations, 4 weeks after planting. For each experiment, the treatment means were analysed using ANOVA with sites as replicates.

The soil pH was measured at each planting with a pH meter using a standard glass electrode after slurrying 50 g dry soil with 50 ml distilled water and allowing it to stand for 15 min.

RESULTS AND DISCUSSION

As a bioassay species white mustard was more sensitive than lentil to both tribenuron and thifensulfuron. The most common effect of both herbicides on the bioassay plants was stunting. For lentils this was due to a reduction in growth of the main stem and branches, and for white mustard due to a reduction in the number of lobes on the leaves and stem shortening. Some similar primary and secondary growth responses of sensitive plant species have been described by Blair and Martin (1988) and Rahman *et al.* (1988).

Of the two herbicides studied, tribenuron was found to have much greater activity in all three soils than thifensulfuron (Tables 1 and 2). In the unlimed soil, tribenuron still caused some damage to the white mustard plants 14 days after application. At this time thifensulfuron had no significant effect on dry matter production of either species. This higher activity of tribenuron compared to thifensulfuron has been previously reported and is largely due to the longer persistence of tribenuron in the soil (Beyer *et al.* 1987; Brown 1990; Moyer 1995).

The overall activity of tribenuron in the lime treatment was significantly higher in the Hamilton clay loam soil than the other two soils 14 days after application. As the phytotoxicity was similar in the three soils on Day 7, this suggests that the residual activity of tribenuron persisted at a higher level in the Hamilton clay loam soil than in the other two soils. Initial soil pH, the main factor affecting the activity and

persistence of these herbicides, was similar in the three soils. It is likely that the differences in soil organic matter levels and the type of clay resulted in different levels of activity (Bayer *et al.* 1987; Brown 1990).

TABLE 1: Effect of lime/burnt lime on herbicide activity in soil as measured by dry matter yield of white mustard planted 7 and 14 days after application.

White mustard dry matter (g/pot)						
Treatment	Rate (g prod/ha)	No lime	Lime	Burnt lime	Lime + water	Burnt lime + water
7 days ^a						
untreated	-	0.96	1.01	1.13	0.92	0.92
tribenuron	25	0.52	0.20	0.06	0.15	0.08
tribenuron	50	0.50	0.09	0.02	0.07	0.03
thifensulfuron	20	0.75	0.73	1.05	0.87	0.68
thifensulfuron	40	0.75	0.62	0.89	0.66	0.44
14 days ^a						
untreated	-	0.89	0.83	1.12	0.72	0.80
tribenuron	25	0.52	0.18	0.09	0.12	0.19
tribenuron	50	0.59	0.12	0.03	0.09	0.07
thifensulfuron	20	0.76	0.87	1.05	0.66	0.61
thifensulfuron	40	0.75	0.80	0.86	0.75	0.51

^a LSD(5%) = 0.28 and applies to differences between any two data.

TABLE 2: Effect of lime/burnt lime on herbicide activity in soil as measured by dry matter yield of lentil planted 7 and 14 days after application.

Lentil dry matter (g/pot)						
Treatment	Rate (g prod/ha)	No lime	Lime	Burnt lime	Lime + water	Burnt lime + water
7 days ^a						
untreated	-	0.33	0.33	0.35	0.36	0.39
tribenuron	25	0.27	0.23	0.18	0.22	0.17
tribenuron	50	0.24	0.16	0.10	0.12	0.11
thifensulfuron	20	0.31	0.33	0.39	0.33	0.33
thifensulfuron	40	0.31	0.32	0.36	0.35	0.30
14 days ^a						
untreated	-	0.31	0.32	0.34	0.30	0.32
tribenuron	25	0.27	0.22	0.19	0.19	0.17
tribenuron	50	0.25	0.15	0.11	0.14	0.10
thifensulfuron	20	0.31	0.30	0.31	0.30	0.32
thifensulfuron	40	0.32	0.32	0.31	0.29	0.30

^a LSD(5%) = 0.08 and applies to differences between any two data.

The application of lime and burnt lime increased the pH of all three soils (Table 3). The effect of burnt lime was greater than that of agricultural lime, presumably due to its greater water solubility. Application of water had no effect on pH levels in the lime treatment but appreciably lowered the pH of burnt lime treatments in all cases.

Applications of both lime and burnt lime before the herbicides were applied significantly increased the activity of tribenuron in all three soils (Tables 1 and 2). The

result of this was to reduce dry matter production of white mustard to 40 - 60% of untreated in the soil without lime and 2 - 20% of untreated in soils with lime or burnt lime, when bioassayed 7 days after the application of tribenuron (Table 1). The corresponding results for lentil were 60 - 80% of untreated in the soil without lime and 6 - 60% of untreated in the soils treated with lime or burnt lime (Table 2). In many cases burnt lime produced a greater effect than ordinary lime, although the overall differences were not significant. However, the application of water produced a significant interaction with the lime and burnt lime treatments, i.e. lime plus water generally resulted in increased herbicidal activity whereas burnt lime plus water generally gave reduced herbicidal activity.

TABLE 3: Soil pH for the three soils measured 7 and 14 days after application of lime.

Soil	pH				
	No lime	Lime	Burnt lime	Lime + water	Burnt lime + water
7 days					
Lismore	5.5	5.9	6.5	5.8	6.1
Hamilton	5.5	5.8	6.7	5.9	6.3
Horotiu	5.6	6.2	7.1	6.4	6.4
14 days					
Lismore	5.6	5.9	6.4	5.8	6.0
Hamilton	5.4	5.8	6.5	5.8	6.1
Horotiu	5.6	6.2	7.1	6.4	6.4

Various lime treatments had little or no effect on the phytotoxicity of thifensulfuron. When used in the absence of lime, the thifensulfuron treatments produced less dry matter but these were not significantly different from the untreated. The addition of lime sometimes resulted in these differences becoming significantly different from untreated but not from the no-lime treatment. In most instances thifensulfuron did not persist long enough in the soil to cause any measurable damage to bioassay species in any of the soils 14 days after application except where the high rate was used with burnt lime and water. The very short lived residual life of thifensulfuron in the soil has been reported previously (Beyer *et al.* 1987; Brown 1990; Moyer 1995).

The results of this study clearly demonstrate increased soil activity of tribenuron if lime is applied prior to spraying of tribenuron in conservation tillage systems. Recently Holloway *et al.* (1995) have reported increased persistence of metsulfuron-methyl where lime was added in rotational forage cropping systems. This effect was noted regardless of the rate of lime used. We included burnt lime in our study because it was thought that agricultural lime may not get into the soil solution in sufficient amounts within a short period to have a significant influence. The data show, however, that agricultural lime did have a significant influence on the soil activity of tribenuron and further that the addition of water had no additional effect to that of the lime in the field moist soils.

It appears that the addition of lime or burnt lime and the resultant increase in soil pH slowed down the chemical hydrolysis of tribenuron, with a consequent increase in both biological activity and soil residual activity of this compound. This demonstrates that tribenuron is very susceptible to chemical degradation, as has been reported by Beyer *et al.* (1987) and Brown (1990). The lack of response of thifensulfuron to the increase in soil pH levels means that it is not affected to the same extent by chemical hydrolysis and that it is much more susceptible to biological and microbial degradation, as has been reported previously (Brown 1990). Based on the results of this study, it is suggested that in the case of tribenuron, a longer waiting period would be required

before planting the recommended crops if lime had recently been applied to the soil. However, this may not be the case with thifensulfuron if it is to be used in similar situations.

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REFERENCES

- Beyer, E.M., Brown, H.M. and Duffy, M.J., 1987. Sulfonylurea herbicide soil relations. *Proc. 1987 Brit. Crop Prot. Conf. - Weeds*: 531-540.
- Blair, A.M. and Martin, T.D., 1988. A review of the activity, fate and mode of action of sulfonylurea herbicides. *Pestic. Sci.* 22: 195-219.
- Brown, H.M., 1990. Mode of action, crop selectivity, and soil relations of the sulfonylurea herbicides. *Pestic. Sci.* 29: 263-281.
- Hay, J.V., 1990. Chemistry of sulfonylurea herbicides. *Pestic. Sci.* 29: 247-261.
- Holloway, J.C., Cole, A.W. and Shaw, D.R., 1995. Effect of soil type and liming rates on rotational forage crop injury following metsulfuron methyl. *Weed Tech.* 9: 286-293.
- James, T.K., Rahman, A. and Mortimer, J., 1989. Biological activity of DPX - L5300 in some New Zealand soils. *Proc. 42nd N.Z. Weed and Pest Control Conf.*: 91-94.
- Kotoula-Syka, E., Eleftherohorinos, I.G., Gagianas, A.A. and Sficas, A.G., 1993. Phytotoxicity and persistence of chlorsulfuron, metsulfuron-methyl, triasulfuron and tribenuron-methyl in three soils. *Weed Res.* 33: 355-367.
- Moyer, J.R., 1995. Sulfonylurea herbicide effects on following crops. *Weed Tech.* 9: 373-379.
- O'Connor, B.P., 1996. Novachem Manual: A New Zealand guide to agrichemicals for plant protection. SwiftPrint Centre Ltd, Palmerston North, pp. 271.
- Rahman, A. and James, T.K., 1991. Influence of soil moisture on the post-emergence activity of nine sulfonylurea herbicides. *Proc. 13th Asian-Pacific Weed Sci. Soc. Conf.*: 13:331-337.
- Rahman, A., James, T.K. and Mortimer, J., 1988. Persistence and mobility of the sulfonylurea herbicide DPX-L5300 in a New Zealand Volcanic soil. *Med. Fac. Landbouww. Rijksuniv. Gent* 53: 1463-1469.
- Riise, G., 1994. Association of tribenuron-methyl with colloidal and particulate materials. *Sci. of the Total Environ.* 152: 91-99.