Pasture uptake from solid and liquid applications of cobalt and copper sulphate

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Abstract

Uptake of cobalt (Co) and copper (Cu) by ryegrass–white clover based pasture was measured from December 1999 to March 2000 at Woodlands Research Station in Southland. Treatments were control, cobalt sulphate ($CoSO_4$) at 120 and 240 g/ha initially and 60 g/ha monthly, and copper sulphate ($CuSO_4$) at 5 and 10 kg/ha initially and 1.25 kg/ha monthly, applied in either solid or liquid forms. At 120 g $CoSO_4$/ha applied as solid and liquid, pasture Co content was significantly ($P<0.05$) elevated above control for up to 3 weeks after application. $CoSO_4$ applied initially at 240 g/ha in both forms significantly increased pasture Co above control for 6–7 weeks after application. For the December monthly application, neither solid or liquid application of 60 g $CoSO_4$/ha significantly increased pasture Co from 2 weeks after application. Later applications resulted in both forms of $CoSO_4$ significantly increasing pasture Co above control for up to 3 weeks after application. Pasture Co was significantly higher from liquid compared to solid application in February and March. When applied in one application, 5 kg solid $CuSO_4$/ha significantly increased pasture copper (Cu) content above control for 3 weeks, 5 kg liquid $CuSO_4$/ha had an effect for 4 weeks, 10 kg solid $CuSO_4$/ha for 5 weeks, and 10 kg liquid $CuSO_4$/ha for 13 weeks. Monthly applications of 1.25 kg $CuSO_4$/ha significantly increased pasture Cu above control for 1–2 weeks after application in all months. There was a significant increase in pasture Cu from liquid compared with solid application in February and March. The short duration of effect of the high rates of $CoSO_4$ and $CuSO_4$ suggest that, if required, they should be applied at a time when the animal can build up stores of Co and Cu in the liver before a critical period. In summer/autumn, when rainfall is lower, $CoSO_4$ and $CuSO_4$ if required, should be applied as liquid, 1 week before the pasture is grazed. These recommendations assume that the increase in pasture uptake of Co and Cu would result in greater Co and Cu availability to the animal.

Keywords: $CoSO_4$, $CuSO_4$, pasture, Co content, Cu content

Introduction

Deficiencies of mainly cobalt (Co) for sheep and copper (Cu) for cattle and deer occur across a range of New Zealand soils. Traditionally, either application of cobalt sulphate ($CoSO_4$) and copper sulphate ($CuSO_4$) in fertiliser or treatment of animals has been used to overcome these deficiencies. More recently, $CoSO_4$ has been mixed with water and sprayed on to pasture as a short-term treatment option to replace animal treatment. Earlier research (Sherrell 1990; Pringle *et al.* 2000) has measured higher pasture Co content from liquid compared with solid forms of $CoSO_4$. The reported trial was carried out to gain further information on the effect of form and rate of $CoSO_4$ on pasture Co, and to investigate the effect of form and rate of $CuSO_4$ on pasture Cu content. The effect of form of $CuSO_4$ has not been previously researched in New Zealand.

Materials and methods

Site and treatments

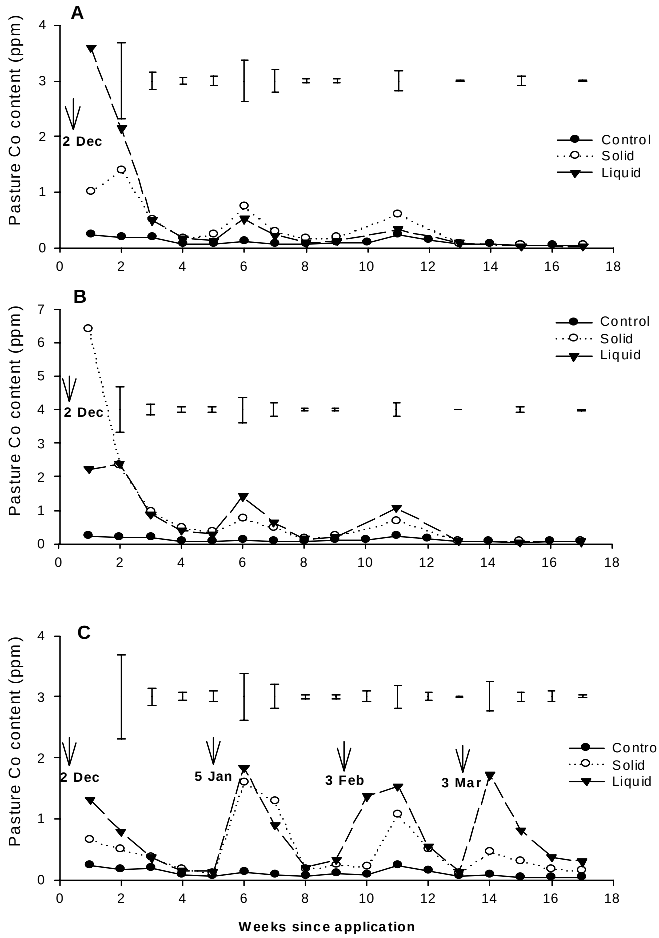
The trial was sited on a 6-year-old pasture originally sown with ryegass and white clover but now also containing other grasses and flatweeds, on a Waikiwi brown soil at Woodlands Research Station near Invercargill. Initial, EDTA-extractable, soil Co was 1.55 ppm, soil Cu 2.95 ppm and soil Mn 201 ppm. The $CoSO_4$ and $CuSO_4$ applied had over 90% of particles in the size range 0.15–0.5 mm. When applied in the solid form, $CoSO_4$ and $CuSO_4$ were mixed with sand. In the liquid form they were mixed with sufficient water to cover the whole plot once and sprayed on to the pasture. Plot size was 15 m^2 and there were 5 replicates of each treatment. The treatments were control, $CoSO_4$ (120, 240 g/ha) and $CuSO_4$ (5, 10 kg/ha) applied on 2 Dec 1999, and $CoSO_4$ (60 g/ha) and $CuSO_4$ (1.25 kg/ha) applied on 2 December 1999, 5 January, 3 February, and 3 March 2000.

Measurements

The once only December application plots were sampled weekly for the first 2 months and fortnightly thereafter.

Plots with monthly applications and controls were sampled weekly from December to March. At each sampling, pasture was clipped from 20 sites in each plot down to sheep grazing height (2–3 cm) and bulked. Each bulked sample was dried at 60°C for 24 hours and analysed for Co or Cu concentration using atomic absorption. Only samples from one replicate were analysed 1 week after the initial application because of a laboratory fire, so no statistical analysis could be carried out. The whole trial site was grazed by ewes for 12 hours every 4–6 weeks when pasture mass reached 2 t DM/ha. Daily rainfall was measured during the trial.

Figure 1 Effect of solid and liquid forms of $CoSO_4$ on pasture Co content for (A) 120 g/ha applied once, (B) 240 g/ha applied once and (C) 60 g/ha applied monthly. Bars are LSD (5%). Arrows indicate application dates.



Results

The effect of form and rate of $CoSO_4$ and $CuSO_4$ on pasture Co and Cu content is shown in Figures 1 and 2 respectively.

Cobalt sulphate

From the single December application, pasture Co from the solid and liquid form was significantly greater ($P<0.05$) than control at 3 weeks after application at 120 g/ha (Figure 1A). At 240 g/ha, both forms resulted in significantly greater pasture Co than control for 6–7 weeks after application (Figure 1B). There were no significant differences in pasture Co between forms at either rate.

With the monthly application of 60 g $CoSO_4$/ha, there was a trend for pasture Co from both forms to increase significantly above control for up to 2 weeks after application and then decline (Figure 1C). Pasture Co from liquid $CoSO_4$ was significantly greater than from solid $CoSO_4$ for 1–2 weeks after the February and March applications.

Copper sulphate

From the single December application of $CuSO_4$, at 5 kg/ha, the solid form significantly increased pasture Cu content above control for 3 weeks and the solid form for 4 weeks (Figure 2A). At 10 kg/ha, corresponding values were 5 weeks for solid and 13 weeks for liquid $CuSO_4$ (Figure 2B). Liquid application resulted in significantly greater pasture Cu than solid application for 5 weeks at 5 kg/ha and 7 weeks at 10 kg/ha.

For monthly applications of 1.25 kg $CuSO_4$, there was a similar cyclical pattern to $CoSO_4$ (Figure 2C). The liquid but not the solid form resulted in a significant increase in pasture Cu over control in December, both forms had pasture Cu significantly greater than control in January (up to 3 weeks after application), and liquid application also resulted in significantly higher pasture Cu than solid application for up to 2–3 weeks after application in February and March.

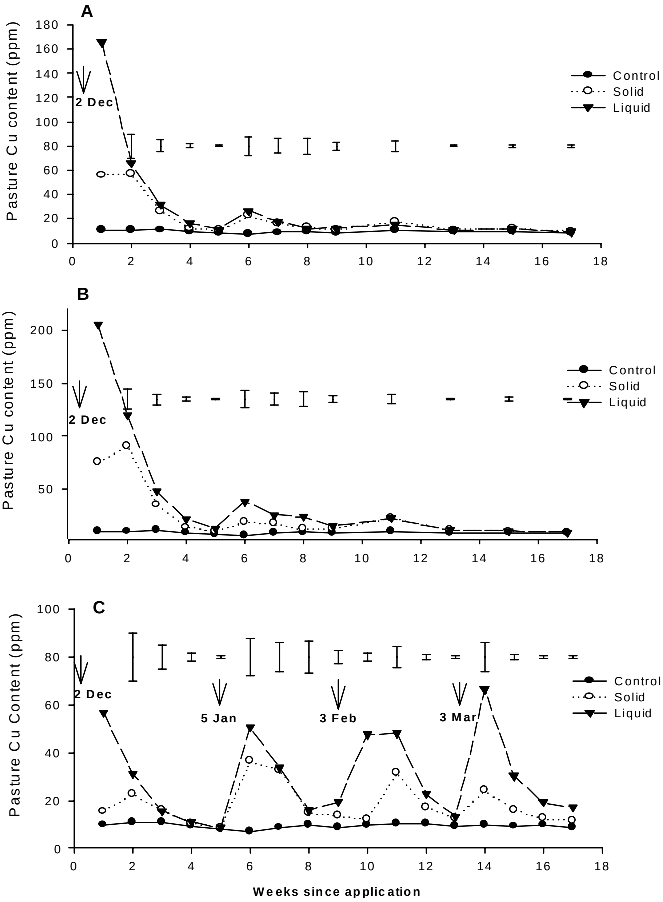
Rainfall

Rainfall in the week following each application date was 15.1 mm in December, 1.5 mm in January, 40.5 mm in February and 13.5 mm in March. Monthly rainfall was 105 mm in December, 87 mm in January, 66 mm in February and 58 mm in March.

Discussion

The 7-week duration of effect of the single application of 240 g $CoSO_4$/ha applied as liquid was similar to that reported by Metherell (1989) at the same rate on the

Figure 2 Effect of solid and liquid $CuSO_4$ on pasture Cu content for (A) 5 kg/ha applied once, (B) 10 kg/ha applied once, and (C) 1.25 kg/ha applied monthly. Bars are LSD (5%). Arrows indicate application dates.



at both 5 and 10 kg/ha was much shorter than the 6-month duration reported by Morton (unpublished results) on pumice soils where the same rates of $CuSO_4$ were applied. In contrast, the effect in our trial peaked at a 16- (5 kg/ha) to 20-fold (10 kg/ha) increase over control compared with a 1.5- to 3-fold increase reported by Morton (unpublished results). This indicates that there may have been a trade-off between the duration and size of the effect at these sites.

The advantage of monthly applications of liquid over solid $CoSO_4$ in February and March but not January was also reported by Pringle *et al.* (2000). There are three possible mechanisms by which application in the liquid form could result in higher pasture Co content than from the solid form. The liquid $CoSO_4$ could be absorbed through the leaf, it could adhere to the leaf, or could be dispersed more effectively in the soil to be taken up by roots, especially at low soil moisture content. It is assumed that all of the solid $CoSO_4$ falls through the pasture canopy and can only be taken up by plant roots. Plants may take up Co through the leaf, however Co taken up this way is practically immobile (Gustafson & Schlessinger 1956) but still could be available to the animal. Root uptake of nutrients is usually much greater than foliar absorption. Rainfall

Waikiwi brown soil at Woodlands Research Station. On a Southland pallic soil, 175 and 350 g $CoSO_4$/ha applied as liquid also increased pasture Co content for 8 weeks but for less than 4 weeks when applied in the solid form (Pringle *et al.* 2000). Sherrell (1990) measured a shorter duration of 4 weeks to a lower application rate of 40 g $CoSO_4$/ha in both solid and liquid form on an allophanic soil. The peak size of the liquid form effect ranged from 6 times (Sherrell 1990; Pringle *et al.* 2000) to 100 times (Metherell 1989) that of control, compared with 10 times in our trial. In the solid form, the peak effect varied from 2–3 times (Sherrell 1990; Pringle *et al.* 2000) that of control, compared with 4 (120 g $CoSO_4$/ha) to 28 times (240 g $CoSO_4$/ha) in our trial. These results suggest that the duration and size of the increase in pasture Co will differ between soil types and years.

The duration of effect of December applications of solid forms of $CuSO_4$ of 3 and 5 weeks respectively

in the week after each application was greater than 12 mm in all months except January, presumably sufficient to wash the soluble $CoSO_4$ off the leaf before the first sampling. There was no significant difference in pasture Co content between forms at the first sampling after the January application indicating that adherence of liquid $CoSO_4$ to the leaf did not occur. The better coverage of liquid $CoSO_4$ on the surface resulting in improved dispersion in the soil is a possible mechanism, as at 60 g/ha, there were only 126 grains/m^2 applied as solid $CoSO_4$. Monthly rainfall did decline from December to March so soil moisture could have limited movement of Co to plant roots in February and March, resulting in an advantage to the liquid form. Lower soil moisture in February and March could also have reduced pasture uptake of soil Co in a situation where soil Mn levels were high (Zheng Li *et al.* 1999). Even if the mechanism for the higher pasture content from the liquid form could not be clearly identified in this trial, the results indicate that application of liquid $CoSO_4$ and $CuSO_4$ is more effective than solid in months with lower rainfall. For Cu, where the effect of form was similar to Co, most of these factors should apply. However improved coverage (800 grains/m^2) from the higher rate of monthly applied solid $CuSO_4$ (1.25 kg/ha) would have been expected to reduce the effect of liquid application increasing dispersion of Cu in the soil.

The peak in pasture Co and Cu at 1 week after monthly application also suggests that for maximum intake by grazing animals, grazing should be carried out at this time. This may mean that application may need to be carried out 2–3 weeks after the previous grazing if the interval between grazings is 4 weeks. Application of high rates of $CuSO_4$ in both forms elevated pasture Cu well above the lower end of the toxic range for sheep (20 ppm) for 2–3 weeks after application so sheep should be withheld from pasture where Cu has been applied for that period.

It must be acknowledged that the effects of the treatments were not measured in terms of animal trace element concentrations. The relationship between pasture and animal trace element status can be confounded by factors such as soil intake of trace elements and the effect of animal molybdenum intake on Cu availability. Any extrapolation of pasture trace element uptake results must take these factors into consideration.

Conclusions

1. High rates of solid (240 kg/ha) and liquid (120 and 240 g/ha) $CoSO_4$ and solid and liquid $CuSO_4$ (5 and 10 kg/ha) applied in early December only elevated pasture Co and Cu content for 2–8 weeks after application. Therefore, if required, high rates of $CoSO_4$ and $CuSO_4$ should be used at a time (late spring for Co, autumn for Cu) that enables lambs (Co) and cattle and deer (Cu) to build up liver stores before critical periods.
2. Monthly applications of solid and liquid $CoSO_4$ (60 g/ha) and $CuSO_4$ (1.25 kg/ha) elevated pasture Co and Cu for up to 3 weeks when applied in early January, February and March but not early December for $CoSO_4$. Liquid applications were more effective than solid applications in February and March. In summer/autumn months with lower rainfall, $CoSO_4$ and $CuSO_4$ if required, should be applied in the liquid form and the pasture grazed 1 week after application for maximum animal intake.

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