The effectiveness of autumn spray applications of cobalt sulphate, copper chelate and copper sulphate on Southland pastures

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Abstract

Uptake of cobalt (Co) and copper (Cu) by ryegrass/white clover based dairy pasture from autumn spray applications of cobalt sulphate ($CoSO_4$) copper sulphate ($CuSO_4$) and Cu chelate was measured at a site near Woodlands in Southland. The rates of application were 0, 12.6, 25.2, 50.5 g Co/ha (0, 60, 120 and 240 g $CoSO_4$/ha), and 0, 0.25, 0.5 and 1 kg Cu/ha. The concentration of Co in herbage was significantly increased initially by the two highest application rates ($P<0.001$). However, only the highest application rate of 50.5 g Co/ha (240g $CoSO_4$/ha) gave increased herbage Co concentrations for the full 41 day duration of this study. In contrast the concentration of Cu in herbage at all rates of application for both forms was significantly higher ($P<0.001$) than that of the control even after 41 days, with the lowest rate of the sulphate form having concentrations similar to the highest rate of the chelate form. The herbage Cu concentrations from the treated plots, immediately following the application, exceeded 100 mg Cu/kg dry matter (DM) for all application rates and forms and dropped steadily until day 27 at which time they were in the range of 20-90 mg Cu/kg DM. Cu concentration remained relatively static from day 27 until the end of measurement at day 41. These levels should be sufficient to supply animal requirements, resulting in liver Cu levels which could remain adequate for the critical winter period. Hence when applied in liquid form, rates of Cu application lower than previously recommended may be sufficient. Despite this, care must still be taken in the first 5-10 days following application to avoid Cu toxicity to grazing animals.

Keywords: copper chelate, cobalt sulphate, copper sulphate, pasture cobalt content, pasture copper content

Introduction

Deficiencies of copper (Cu) for cattle and deer, and cobalt (Co) for sheep can occur across a range of New Zealand soils. Traditionally applications of copper sulphate ($CuSO_4$) or cobalt sulphate ($CoSO_4$) have been added to fertilisers as an alternative to the direct treatment of animals as a means of overcoming these deficiencies. However the magnitude of the pasture response is dependent on soil status and pasture composition, with clover known to have a higher content of Cu and Co than grasses (Grace 1992; Sherrell & Rawnsley 1982; Sherrell 1990b). Earlier work (Pringle *et al.* 2000; Morton & Smith 2000) has suggested that applications of liquid $CoSO_4$ resulted in higher plant concentrations than applications of the solid form when applied in summer. Sherrell (1990b) also found that liquid Co applications resulted in higher initial plant concentrations, but this difference was relatively short lived. Grace (2002) has suggested that applying 12 kg Cu SO_4/ha in late-March was effective in maintaining an adequate Cu status of grazing deer for up to at least 10 months, provided herbage levels are increased to at least 45 mg Cu/kg dry matter (DM) for at least 8-12 weeks. However Morton & Smith (2000) found a short duration of effect of high rates of $CuSO_4$ from summer application, which suggests that $CuSO_4$ should be applied at a time when the animal can build up stores of Cu in the liver before a critical period. They also found that immediately following application, pasture levels of Cu were elevated sufficiently to cause some animal health concerns. The trial reported here was carried out to investigate whether autumn-applied Co gives similar results to summer applications, and whether lower rates or the use of a different form of Cu may be one way of alleviating the delay between application and grazing, while still elevating pasture Cu levels sufficiently to supply the animal requirements.

Materials and methods

Site and treatments

The trial was sited at Morton Mains in Southland on a farm which was in its second year of dairying after conversion from a sheep farm. The pasture used was a 10-15 year old ryegrass/white clover one. The soil was classified as a Waikiwi silt loam, a typic firm Brown soil (Hewitt 1998). Pasture molybdenum (Mo) concentrations at the commencement of the trial averaged 0.32 mg/kg (range 0.10 to 0.55). The treatments applied were copper chelate (Ravensdown SUPA COPPER® 6% copper EDTA chelate), $CuSO_4$ and $CoSO_4$. Rates of application were 0, 0.25, 0.5 and 1.0 kg Cu/ha (0, 1, 2 and 4 kg $CuSO_4$/ha and 0, 4.2, 8.3 and 16.7 l Cu chelate/ha) and 0, 12.6, 25.2 and 50.4 g Co/ha (0, 60, 120 and 240 g $CoSO_4$/ha). All minerals were applied by knapsack sprayer with a water rate of 200 l/ha, together with a sticker (Super wet oil ® at recommended rates). To ensure all the crystalline copper and cobalt sulphates were fully dissolved, the appropriate amounts for each treatment were placed in 1 litre of water 24 hours before application and allowed to fully dissolve. Plot size was 20 m^2 and there were 6 replicates of each treatment. All treatments were applied on 1 April 2003, between 9.00am and 10.30am. The trial area had been grazed by dairy cows 4 days before treatment, and was re-grazed in early – May just prior to the final sampling. Daily rainfall was measured at the Woodlands Research Station 7 km west of the site.

Measurements

Pasture samples were collected from each plot every five days following application, with the first sample collected 2 hours after the last treatment was applied. After 20 days the sampling frequency was increased to weekly for a further 3 weeks. At each sampling time pasture was cut with hand shears at 15-20 sites within each plot, avoiding the end and side margins, and bulked. These bulked samples were dried at 65-70°C for up to 3 days in a fan oven until weights were constant. To avoid cross contamination all control samples were dried in a separate oven for the first 3 weeks while for the first 3 samplings (days 0, 5 and 10) the samples from the copper chelate and $CuSO_4$ treatments were also dried separately. On day 5 it was noticed that some of the plots were showing signs of 'burn' damage to the clover leaves, hence on day 10 a visual rating (0-5) of this damage was done for each plot. However, this damage was short lived as by day 15 it was less visible and the pasture appeared to be out-growing it.

Results

Cobalt

The application of liquid $CoSO_4$ in April resulted in immediate and significant increases in herbage Co concentrations, with some of these increases lasting for the full 41 days of measurement (Figure 1). However at the lowest application rate of 12.6 g Co/ha (60 g $CoSO_4$/ha) the herbage Co concentration returned to similar levels to that of the control after 41 days, while at the highest application rate of 50.5 g Co/ha (240 g $CoSO_4$/ha) the herbage concentration remained significantly higher ($P<0.001$).

Copper

The application of Cu chelate and $CuSO_4$ to herbage resulted in immediate and large ($P<0.001$) increases in herbage Cu concentrations (Figure 2). While there was

Figure 1 Effect of liquid $CoSO_4$ rates applied on 1 April on pasture Co content. The horizontal line indicates critical pasture Co concentration (0.08 mg/kg) for sheep while bars are SED.

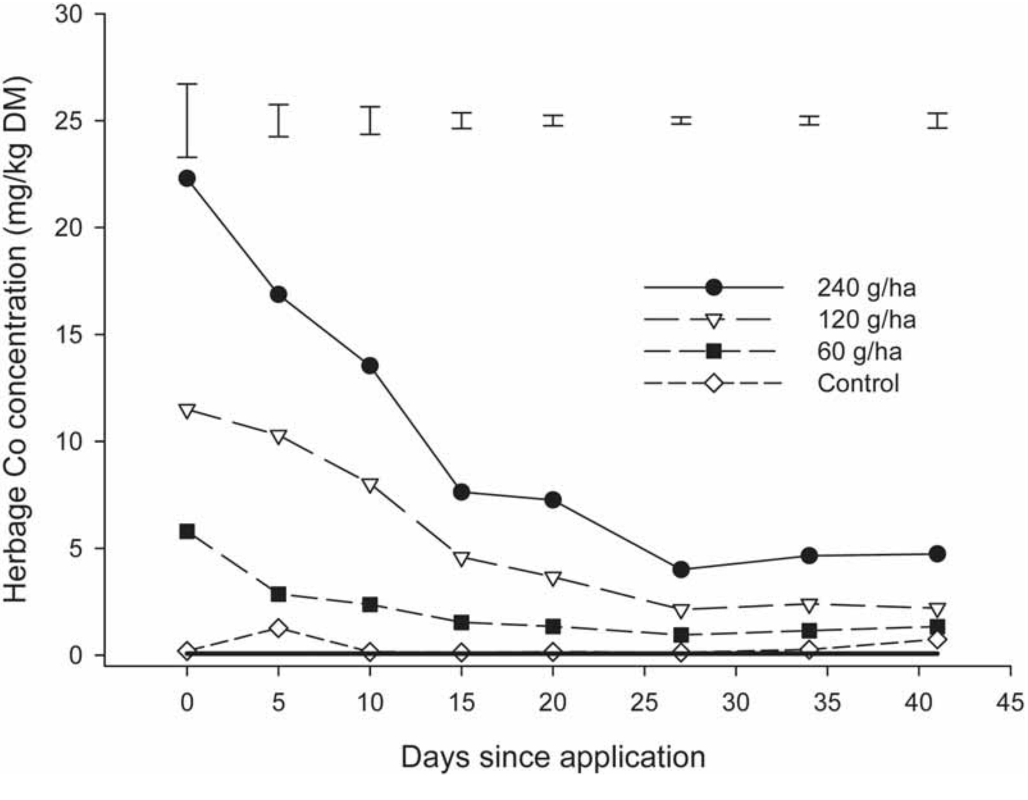


Figure 2 Effect of liquid $CuSO_4$ and Cu chelate rates applied on 1 April on pasture Cu content for (A) 1.0 kg Cu/ha, (B) 0.5 kg Cu/ha and (C) 0.25 kg Cu/ha. Bars are SED.

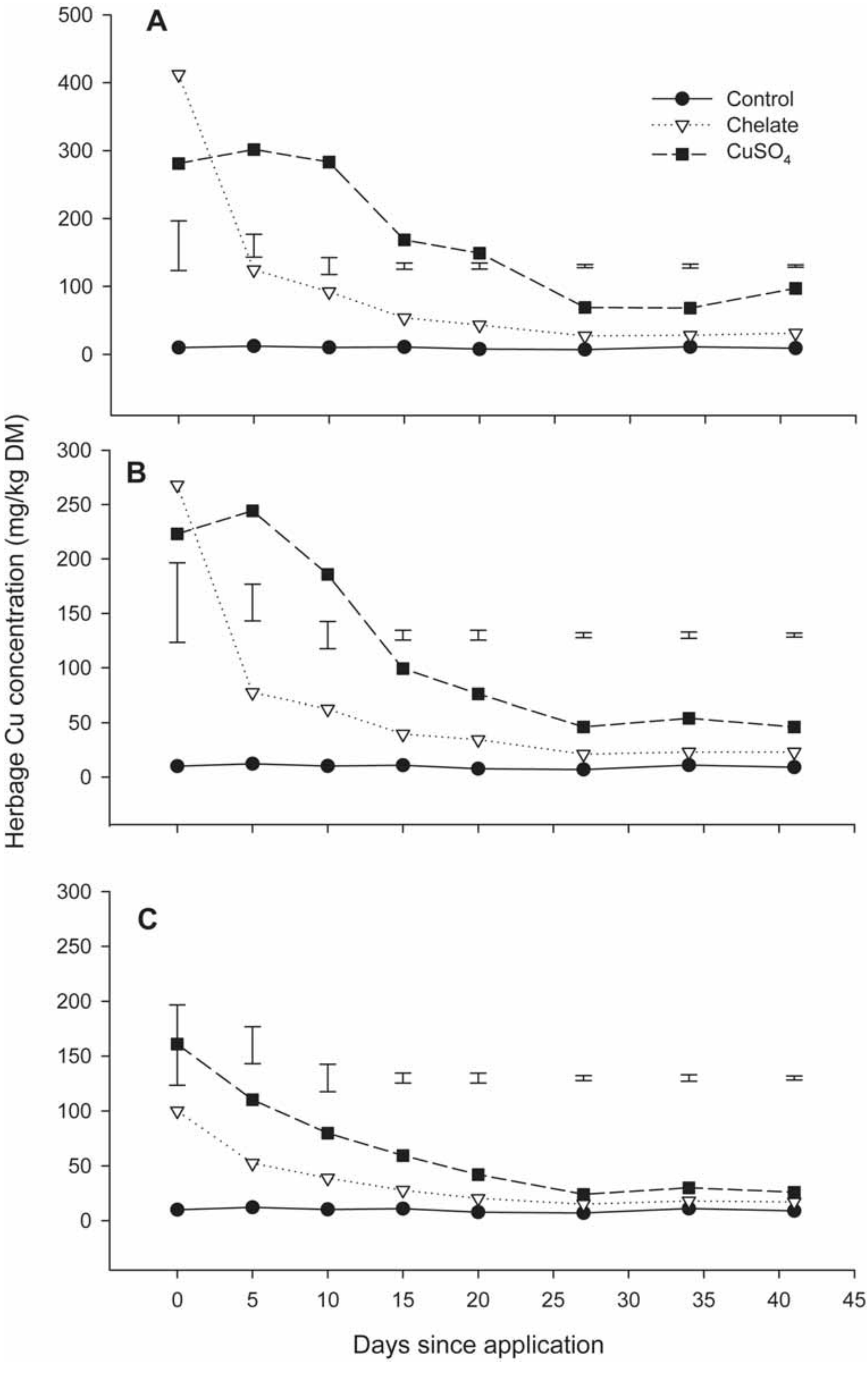
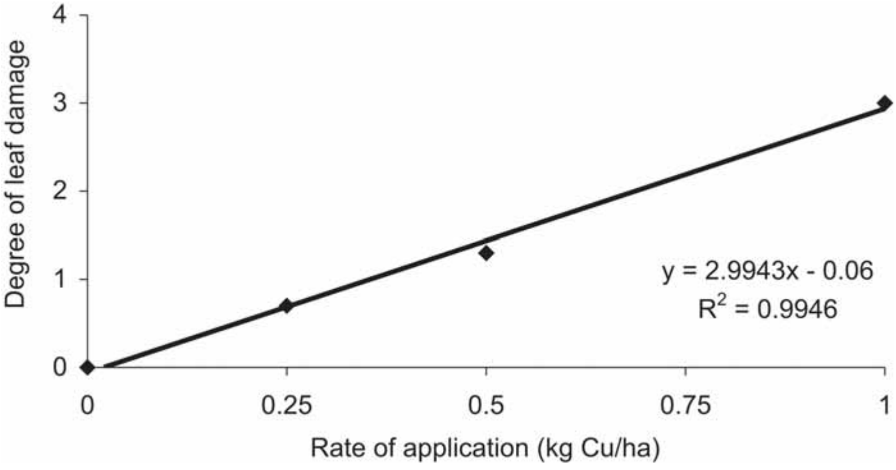


Figure 3 Relationship between visible leaf damage as measured 10 days after application and Cu chelate application.



initially no statistically significant difference between the two forms of copper on day 0, for the two highest application rates (0.5 and 1.0 kg Cu/ha) the Cu chelate gave slightly higher herbage concentrations of Cu than the $CuSO_4$ (Figure 2A & B). By day 5 and at every measurement day after then, the $CuSO_4$ gave significantly higher herbage Cu concentrations ($P<0.001$) than the Cu chelate at all application rates. The concentrations of Cu in herbage at all rates of application for both forms were significantly higher ($P<0.001$) than those of the control for the 41 days of the measurement, with the lowest rate of the sulphate form having Cu concentrations in the herbage similar to the highest rate of the chelate form.

Leaf damage

Leaf damage or 'burning' to the clover plants was observed in all the chelate treated plots until 15 days after the treatments were applied but only observed in one of the $CuSO_4$ treated plots. For this latter plot the damage was on the side margin close to the Cu chelate plot next door which suggests the damage may have been caused by spray drift of the Cu chelate. The damage increased as the application rates of copper chelate increased (Figure 3).

Rainfall

The application of the treatments occurred after 7 mm of overnight rain, hence the foliage was wet. There was no rain between application and the first sampling 2 hours later. Weekly rainfall totals for the 7 weeks following application were 13, 17, 16, 7, 7, 24 and 55 mm.

Discussion

The 6 week duration of the effect of the Co liquid application was similar to that found previously in Southland (Morton & Smith 2000; Metherell 1989), while for the $CuSO_4$ it was longer (Morton & Smith 2000). However in this experiment the maximums reached in the first 5 days following application for both Co and Cu were somewhat higher than those found by Morton & Smith (2000), but for the Co were similar to that of Metherell (1989). Both these previous studies were conducted with late spring/summer applications. While effects of autumn applications as used here follow similar patterns to these earlier ones, the duration of the effect was longer, perhaps due to the slowing of pasture growth in autumn and hence a greater concentration of Co or Cu within the plant. This occurred despite the application rates of the Cu used in this study being lower than those of Morton & Smith (2000). It is possible that the initial higher concentrations are due to the adherence of the spray to the surface of the plant rather than movement into the herbage. While this could account for these higher concentrations with lower application rates, there was sufficient rainfall in the first 3 weeks of the trial to wash the chemicals off the leaves, so that uptake through the roots could occur. The Co results measured here further confirm the findings of earlier workers (Morton & Smith 2000; Pringle *et al.* 2000) where spray applications result in significant pasture Co increases, but also indicate that these increases in pasture Co levels can be extended into the autumn with a second application for those few occasions where this may be necessary. This is more likely to occur on soils with low Co and no history of Co application (Sherrell 1990a), than on soils with a history of Co application due mainly to the reserves of Co in the soil maintaining higher Co concentrations for longer (Sherrell *et al.* 1990).

The increase in both duration and concentration of Cu in the herbage is beneficial as Grace (2002) suggested that the pasture Cu levels must be at least 28 mg Cu/kg DM at day 28 and remain elevated for 60 to 100 days for Cu topdressing to be effective. This threshold was reached at the highest application (1.0 kg Cu/ha) rate for the Cu chelate and the top two rates (0.5 and 1.0 kg Cu/ha) for $CuSO_4$. Thus where liquid forms of copper are applied, the application rates could be lower with a similar effect to those higher rates of solid forms used previously (Grace 2002). While this study only lasted for 6 weeks, the elevation of the pasture Cu levels during this period could be an effective tool in increasing animal Cu status beyond this time. This is because the liver Cu levels in the animals grazing the pasture over this period could be expected to be elevated and as such would extend the protection beyond the duration of the elevated pasture levels. Indeed Knowles *et al.* (1998) suggested that this protection for sheep would last for nearly twice the duration of the elevated pasture. Elevating pasture Cu for 100 days, resulted in maintaining adequate liver Cu levels in deer for up to 10 months (Grace *et al.* 2001).

It is generally recommended that animals be prevented from grazing Cu amended pastures for between 1 to 4 weeks (Morton & Smith 2000; Grace *et al.* 2003), to allow the Cu fertiliser to be washed into the soil and taken up by the plant, and to allow the initially high plant concentrations to fall to a safe level. Low rates of liquid applications, as used here, could be expected to reduce the time required for the former to occur. However the latter would still be of concern as high pasture Cu can be toxic to stock, with the levels at which this occurs depending on the category of stock grazing pasture as sheep are more susceptible than cattle or deer to Cu poisoning. There are even differences in breeds of sheep, e.g. Texel, which are more susceptible to Cu toxicity because they are more efficient in absorbing dietary Cu (Wolliams *et al.* 1982). Pasture with low Mo (0.1 mg Mo/kg DM) and high Cu (near 20 mg Cu/kg DM) is generally considered to be toxic (Grace 1994). However later work has indicated that concentrations of Cu as high as 41 mg/kg DM can be grazed by Romney sheep without any undue effects (Grace *et al.* 1998). From the results of this study it appears that, depending on application rates, stock would have to be excluded for at least 15 days after the application of Cu for Cu levels to be lower than these critical values. As some classes of stock such as deer appear to be more tolerant of higher pasture Cu, it may be that these stock could graze treated pastures before this time. However more work would be required to confirm the upper limits for these animals before this could be generally recommended.

The reason for the Cu chelate 'burning' the clover leaves in the pasture initially is not known. However Cu chelate is used in several parts of the world as a 'defoliant' in young fruit trees (Faby 1988, 1989; Guak *et al.* 2001) at concentrations similar to these used here (2-9% vs 6%). Hence one possible explanation is that the Cu chelate initiated abscission in the clover leaves, partially due to their being of more horizontal growth pattern in relation to the spray than the ryegrass leaves. Despite the legume outgrowing this 'burning' effect, or rainfall washing the chemical off the leaves, it appears from this study that the EDTA chelated form of Cu was no more effective at supplying Cu to herbage than the sulphate form. One reason for this may be the low pasture biomass at application as previous workers have found that chelated Cu is ineffective if it is required to pass into the soil before being taken up by the plant (McLaren & Williams 1981). However in order to avoid the problem of high initial levels as discussed earlier, it would be advantageous to apply the Cu to freshly grazed pasture, which would then have some time for the levels to drop before the animals returned. In this situation the greater cost of the chelate coupled with its poorer performance would discourage it use.

Conclusions

1. Application of liquid $CoSO_4$ at a rate of 50.4 g Co/ha (240 g $CoSO_4$/ha) in early-April elevated pasture Co concentrations for 41days. At lower rates of application 25.2 g Co/ha (120 g $CoSO_4$/ha) the pasture Co concentrations were elevated for 34 days.
2. Application of liquid Cu as Cu chelate in early-April at rates of 0.5 and 1.0 kg Cu/ha or $CuSO_4$ at rates of 0.25, 0.5 and 1.0 kg Cu/ha resulted in pasture concentrations being maintained above 20 mg/kg DM for at least 41 days.
3. These pasture concentrations for this period of time should be sufficient to allow animals (deer and cattle) to build up liver stores of Cu prior to the winter critical period.
4. These application rates are lower than previously recommended, however care must still be taken when grazing the pasture within 14 days of application.

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