Copper supplementation of grazing cattle using pasture topdressing and individual animal treatment

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Abstract

Three methods of copper supplementation were compared in 9- to 15-month-old Friesian bulls on a farm with a history of copper deficiency. A group of 60 bulls grazed 19 ha which had been topdressed in May with 120 kg copper sulphate (6.3 kg/ha). Five of the bulls were identified for repeated sample collection. A second group of 60 bulls grazed an untreated area and five of these were each given a 20 g copper capsule (Cuprax), five were injected with 100 mg calcium copper edetate (Coprin) and five were not supplemented with copper and served as controls. The response to supplementation was assessed by monitoring liver copper concentrations of the designated five bulls in each treatment plus the five control bulls at 34, 78, 121, 197 and 314 days after treatment. Pasture copper concentrations increased on the topdressed area from 12 to 25 ppm DM for 6 weeks and subsequently remained at 10 ppm for the remainder of the trial. Pasture molybdenum concentrations were low (0.3–0.5 ppm DM) initially and rose to 1.0–1.2 ppm DM during spring on both grazing areas. Despite the elevation of pasture copper, liver copper concentrations of the bulls grazing the topdressed pasture declined in a similar way to the controls. However, at slaughter, day 314, the bulls grazing the copper topdressed area had higher liver copper concentrations than the controls ($P = 0.099$). Copper capsules resulted in a significant elevation of liver copper concentration throughout the trial. Copper calcium edetate injection did not significantly increase liver copper concentrations. More information on the factors affecting copper uptake by grazing ruminants is required.

Keywords: cattle, copper deficiency, dietary supplements

Introduction

Since peat scours in cattle was reported in New Zealand almost 50 years ago (Cunningham 1950) a significant amount of research on the metabolism of copper has been undertaken. Few positive response trials to supplementation have been reported despite the widespread incidence of copper deficiency in cattle.

In the past, topdressing of pasture with 5 to 10 kg/ha of copper sulphate was the most common means of preventing copper deficiency in New Zealand ruminants. More recently, the increasing cost of copper compounds has favoured individual animal supplementation, especially where stocking ratios are low and cattle, but not sheep, require treatment on the same farm. In addition, the elucidation of the role of dietary molybdenum, sulphur and iron in antagonising the uptake of copper (Humphries *et al.* 1983; Phillipo *et al.* 1987) has contributed to the view that copper topdressing may be ineffective in cases of secondary deficiency. Typically less than 5% of dietary copper is absorbed by adult grazing ruminants.

It is generally accepted that, where herbage copper is “low” (5–7 ppm DM), copper topdressing may raise pasture copper concentrations for up to 4 years. On pumice soils planted in lucerne, a single application of 5–6 kg/ha of copper sulphate raised herbage copper concentrations to 8–10 ppm for at least 4 years (Sherrell 1989). These trials assessed the copper supplementation of lucerne but not of grazing ruminants, and single annual samples only were assessed. In contrast, on Northland soils rates of copper sulphate as high as 32 kg/ha failed to provide long-term copper concentrations above 10 ppm (O’Connor 1992). Herbage copper was assessed only at the end of the trial and not at regular intervals after application. Where herbage copper concentrations have been assessed an increase during the three months after application has been noted (Willimont pers. comm).

Soil, plant and animal studies are required to determine the efficacy of copper topdressing as an animal supplement.

Materials and methods

Farm

A controlled copper supplementation trial conducted the previous year on this bull beef property had demonstrated a statistically significant weight-gain response in 18-month-old Friesian bulls given a 20 g copper capsule (Cuprax, Mallinckrodt Ltd, Upper Hutt). During September and October copper concentrations in the liver and serum of the control bulls were in the responsive reference range (West *et al.* 1997).

Animals and methods of supplementation

Three methods of copper supplementation were compared: topdressing, injection and capsule. Response to supplements was assessed by comparing the liver copper concentrations of control animals with those of the supplemented groups.

On 8 May, 120 kg copper sulphate mixed with 3000 kg North Carolina reactive phosphate rock was applied by truck to 19 ha of the farm (average 6.3 kg/ha of copper sulphate). On 14 May, 60 9-month-old Friesian bulls were introduced to the topdressed area. Five bulls were selected at random and identified by an additional eartag for regular liver biopsy.

A second group of 60 9-month-old Friesian bulls grazed an untreated area of 21 ha adjacent to the copper topdressed area and separated by a gully about 50 m wide. From this second group of bulls the following treatment groups were selected at random and identified by an additional eartag for regular liver biopsy.

Control	-	5 bulls not supplemented with copper
Capsule	-	5 bulls given 20 g copper capsules (Cuprax)
Injection	-	5 bulls injected with 2 ml (100 mg) calcium copper edetate (Coprin, Mallinckrodt Veterinary Limited, Upper Hutt)

Liver copper

Liver samples were collected by biopsy (West & Vermunt 1995) from the 20 bulls before treatment (12 May) and on days 34, 78, 121 and 197 after treatment. Liver samples were also collected when the bulls were slaughtered (day 314). The copper concentration of the liver was analysed by atomic absorption spectrophotometry and reported on a fresh weight basis.

Pasture analysis

Pasture herbage samples were collected from the topdressed and untreated areas by walking diagonally across each field, stopping every 10 m to pluck grass, taking care to avoid soil contamination. A minimum of 100 pluck samples were collected from each of the two areas on days 0, 1, 14, 28, 42, 84, 114, 148 and 203 after topdressing with copper sulphate. The combined pasture sample from each area was analysed for copper concentration reported on a dry matter basis.

Statistical analysis

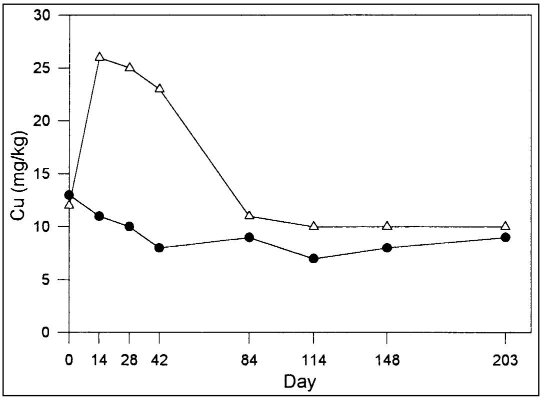
Statistical analysis was conducted using SAS for Windows version 6.10. The SAS procedure PROC MIXED was used to perform a repeated measure analysis of variance.

Results

Pasture analysis (Figure 1)

At the first sampling, after topdressing (14 days), there was a marked elevation of pasture copper concentration on the topdressed area which peaked at about 25 ppm and was maintained for a short period, but returned to pre-treatment levels by 84 days. For the remainder of the trial the pasture copper concentrations did not fall below 10 mg/kg on the topdressed area. On the untreated area, pasture copper concentrations were initially 13 ppm but fell to 7 and 8 ppm during June to October.

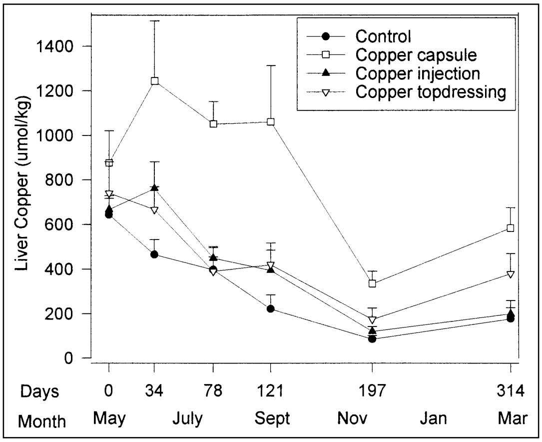
Figure 1 Copper concentrations in bulked herbage samples of pasture topdressed in May with 6.3kg/ha of copper sulphate (—r—) compared with untreated pasture (—●—). (Results on DM basis.)



Liver copper concentrations

The mean liver copper concentrations of the bulls measured before supplementation was considerably higher than the concentration of similar-age bulls measured the previous year (732 µmol/kg cf. 183 µmol/kg). This difference probably reflects the different rearing methods and farms of origin of the young bulls. Despite the higher starting point, liver copper concentrations in the unsupplemented bulls fell progressively and by November the mean was 86 µmol/kg, a concentration considered marginal for copper (Ellison 1992) (Figure 2). Liver copper concentration had increased by the time of slaughter in March to 178 µmol/kg and it is doubtful if a production advantage to copper supplementation would have occurred despite the previous year's finding of a positive weight gain response. Herds with mean liver copper concentration greater than 300 µmol/kg in May are unlikely to fall into the responsive range during spring (Ellison 1994).

Figure 2 Liver copper concentrations of bulls supplemented with copper either by injection, capsule or topdressing compared with control (n=5, Mean, SE).



Copper topdressing

Despite the significant increase in pasture copper concentration for the 6 weeks after topdressing, the liver copper concentration of the bulls grazing treated pasture declined in a similar way to that of control bulls. In November the bulls grazing the copper-topdressed area had mean liver copper concentration of 175 µmol/kg compared with 86 µmol/kg in the controls (P = 0.11). By March, day 314, the liver copper concentration of the bulls grazing the copper topdressed area had increased to 380 µmol/kg, which was significantly higher than that of the control bulls (187 µmol/kg) at the 10% level (P = 0.099).

Copper capsules

There was a marked increase in the liver copper concentration of the bulls treated with copper capsules (Figure 2). At the first post-treatment sampling, 34 days after supplementation, the mean liver copper concentration exceeded 1200 µmol/kg and remained numerically above pre-treatment levels for at least 121 days. The mean liver copper concentration of the copper-treated bulls was significantly higher than that of the control bulls throughout the trial until the slaughter, 11 months after treatment.

Copper injection

At the first sampling 34 days post-treatment, the mean liver copper concentration of the bulls that received 100 mg elemental copper had risen from 639 µmol/kg to 762 µmol/kg. This difference was not statistically significant (P = 0.274). Thereafter the mean liver copper concentration of the copper-injected cattle closely followed that of the control bulls (Figure 2).

Discussion

Young Friesian bulls introduced to this farm each year show a steady fall in liver copper concentration from the May/June period (approximately 9 months of age) until the end of the year. Topdressing pasture with 6.3 kg/ha of copper sulphate substantially increased pasture copper concentration but this was not reflected in liver copper concentration of the bulls. If it is estimated that the bulls consumed 7 kg dry matter per day and the topdressed pasture contained an additional 15 mg/kg copper, this is equivalent to an additional 105 mg copper per day. Over 6 weeks they would have ingested about 4.5 g of additional copper.

In comparison, in bulls given a 20 g capsule of copper oxide wire particles (16 g copper), liver copper concentration increased significantly. Within a few hours of ingestion the capsule dissolves, releasing the particles of copper wire into the rumen. The wire particles progress to the abomasum and dissolve in the acid environment so that peak storage levels of copper are attained about 6 weeks after administration (Wakelin 1992). The point of dissolution in the abomasum is beyond the interfering effects of molybdenum and sulphur, which complex with copper in the rumen to form insoluble thiomolybdates (Grace 1994). Molybdenum concentration of pasture ranged from 0.4 to 0.7 ppm during the time the bulls grazing topdressed pasture were ingesting additional copper. It is possible that these "low" levels of molybdenum may be sufficient to interfere with the absorption of copper from pasture. More research is required to quantify the factors affecting copper uptake from pasture by grazing ruminants.

Copper sulphate topdressing improved the overall copper status of the bulls, and although the pasture response was relatively short lived, copper topdressing may increase the longer-term availability of copper. Repeated applications of copper each year would probably enhance this increase in availability.

Copper injections provide a relatively small amount of copper which could not be detected in this trial owing to the relatively high liver concentrations of copper initially and the relatively small number of bulls sampled. Despite these results there are no published reports of copper injections failing to prevent clinical signs of copper deficiency in New Zealand.

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