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FERTILISER-COATING TECHNOLOGY TO IMPROVE THE EFFICIENCY OF COPPER UPTAKE IN PASTURES

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Abstract

Current practice for trace element (TE) application is to admix granular trace elements in with macro-elemental fertilisers. Although the correct rate of trace elements per hectare can be applied, the distribution of the trace elements can be variable, depending on the trace element application rate, the macro fertiliser it's mixed in with, and the particle size of the trace element granule.

We report the results of a pasture trial where a polymer-coating technology (Surflex) was used to coat a copper compound (Cu_2O) around the SSP fertiliser instead of the standard Cu addition treatment where the $CuSO_4$ compound is admixed in with the SSP fertiliser. The Surflex Cu-coated fertiliser significantly increased both pasture plant uptake of copper and use efficiency (18-38% above control Cu levels compared with 12-27% for standard treatment) over 192 days after application. Further work is required to understand the mode of action behind this increase, however, there is an assumption that the probable improvement in distribution of copper across the trial plots, and the use of cuprous oxide, which is insoluble in water, has some influence over the increased nutrient uptake efficiency.

In addition to the increased plant nutrient uptake, there were observed product quality improvements at time of dispatch, and when applied by the trial operators. As well as coating the trace element to the SSP, the polymer also binds a large proportion of dust and fine particles. This has benefits both environmentally for a potential reduction in product drift when aerially spread, and health and safety of people handling and loading the product.

Keywords

Surflex, Cu, trace elements,

Introduction

The identification of copper (Cu) deficiency in New Zealand in the 1930's and 40's as a chief cause of stock ill-thrift, especially in young animals, led to the top-dressing of pasture with the metal salts of this element (Ellison, 2002). Usually admixed in with other fertilisers, such as superphosphate, the top-dressing of pastures successfully alleviated soil deficiencies of Cu and reduced the incidence of stock health disorders by increasing the concentration in pasture herbage. However, any increase in herbage Cu concentration can be relatively short-lived and so, to maintain these, often requires annual application, and at rates many times the quantities taken up in herbage. Soil pH and levels of organic matter strongly influence Cu availability to plants from soil solution (Carey *et al.*, 1996). However, the continual application of Cu to soils has also raised some potential environmental concerns. Hence, there is a desire to increase usage efficiency and reduce the quantities needed, and this has informed the work presented.

Current practice for trace element (TE) application is to admix granular trace elements in with macro-elemental fertilisers. Although the correct rate of trace elements per hectare can be applied, the distribution of the trace elements can be variable, depending on the trace element application rate, the macro fertiliser it's mixed in with, and the particle size of the trace element compound used. Historically, the relatively small application rates of the desired TE has limited their use in macro fertilisers where the compound can be "bulked out" to ensure relatively even spreading. However, new technology from Southstar Fertilizers has enabled differing TE compounds to be coated around a carrier macrofertiliser using a new polymer coating. This increases the evenness and reliability of TE distribution, along with the ability to customise the rate and number of TEs applied. The technology ensures the application of the TE polymer to the outside of the macro fertiliser granule so that every macro nutrient granule has a coating of the intended trace element.

The objective of this trial was to assess the efficacy of the new polymer coating technology for increasing and sustaining Cu uptake in pasture from superphosphate-coated fertiliser, and was compared with the standard Cu-admixed (as copper sulphate) superphosphate product.

Materials and Methods

Trial site

The trial site was located on a perennial ryegrass-white clover pasture at the Lincoln University Research Dairy farm (LURDF; 43 38 16S 172 27 29E) on a Paparua sandy loam. The pasture was mown down to 1600 kg DM/ha to simulate a grazing event prior to trial establishment. Climate data was taken from the climate monitoring station at the research farm.

Table 1. Selected soil properties (0-75 mm) for the Paparua soil from the trial site.

Property	Value
pH	6.1
Olsen-P	16 μg ml^{-1}
Exch-Ca	7.4 $cmol^{+}$ kg^{-1}
Exch-Mg	0.5 $cmol^{+}$ kg^{-1}
Exch-K	0.1 $cmol^{+}$ kg^{-1}
Exch-Na	0.1 $cmol^{+}$ kg^{-1}
CEC	13.5 cmol kg^{-1}
Sulphate-S	5 μg g^{-1}
Organic-C	2.3% g g^{-1}
Total-N	0.18% g g^{-1}
Base saturation	62%
Soil texture	Fine sandy loam

Treatments

A pasture plot trial was set up consisting of six treatments replicated 17 times in a randomized block design (plots 5 m x 1 m; 102 in total). Treatments were all superphosphate-based products, applied on March 29 2017 at 40 kg P/ha, and the TEs were either combined in a polymer-coating (Surflex) to the main fertiliser or admixed as solid coper sulphate ($CuSO_4.5H_2O$) granules targeting a specific concentration of 15,600 mg Cu/kg SSP. Actual Cu concentrations of treatments are shown in Table 2.

Table 2. List of trial treatments and concentration of Cu in superphosphate.

No.	Treatment ID	Treatment	Cu mg/kg
1	SSP (Control)	Single superphosphate (9% P)	0
2	SSP+$CuSO_4$	Single superphosphate+ solid $CuSO_4$	18,700
3	SSP+Srflx-Cu	Single superphosphate+Surflex coated Cu_2O	15,100
	Target fertiliser Cu concentration		*15,600*

Measurements and data analysis

Climate and rainfall data were collected from the LURDF climate station on-site and compared with recent long-term means (2000-2016). Plots were mown once growth exceeded 3200 kg DM/ha or after six weeks, whichever came first. A single strip, 0.45 m wide, was taken and its fresh weight recorded, after which, the remaining area was mown. The fresh weigh sample was mixed and a representative sample taken for analysis. Pasture dry-matter (DM) was calculated by drying an herbage sample at 65°C for 48 hours. The dried sample was then sent to ARL Ltd. for Co and Cu analysis as well as the normal suite of nutrient analyses. Total DM for each plot was calculated and all data was statistically analysed using ANOVA followed by Fisher's unprotected LSD test.

Results and Discussion

Climate

Rainfall was higher than average over the trial period, particularly in April and July 2017 with air temperatures generally lower than average, particularly over late April and May. Soil temperatures appeared to be considerably higher than average but this may be an artefact of the long-term mean being from the nearby NIWA's Broadfields station rather than on-site where no long-term data is available. Nevertheless, LURDF means were simlar to soil temperature data at nearby Ashley Dene (not shown).

Pasture Cu content

The SSP+$CuSO_4$ and Surflex+Cu_2O treatments increased pasture herbage Cu concentrations (unadjusted) significantly ($P<0.001$; Table 3) by 18% and 28% after the first harvest, 20% and 29% after the second, and 13% and 17% after the third, respectively. Pasture herbage-Cu concentrations in the Surflex-Cu_2O treatments were significantly greater ($P<0.05$) than those for the SSP-$CuSO_4$ in harvest 1, and overall ($P<0.05$).

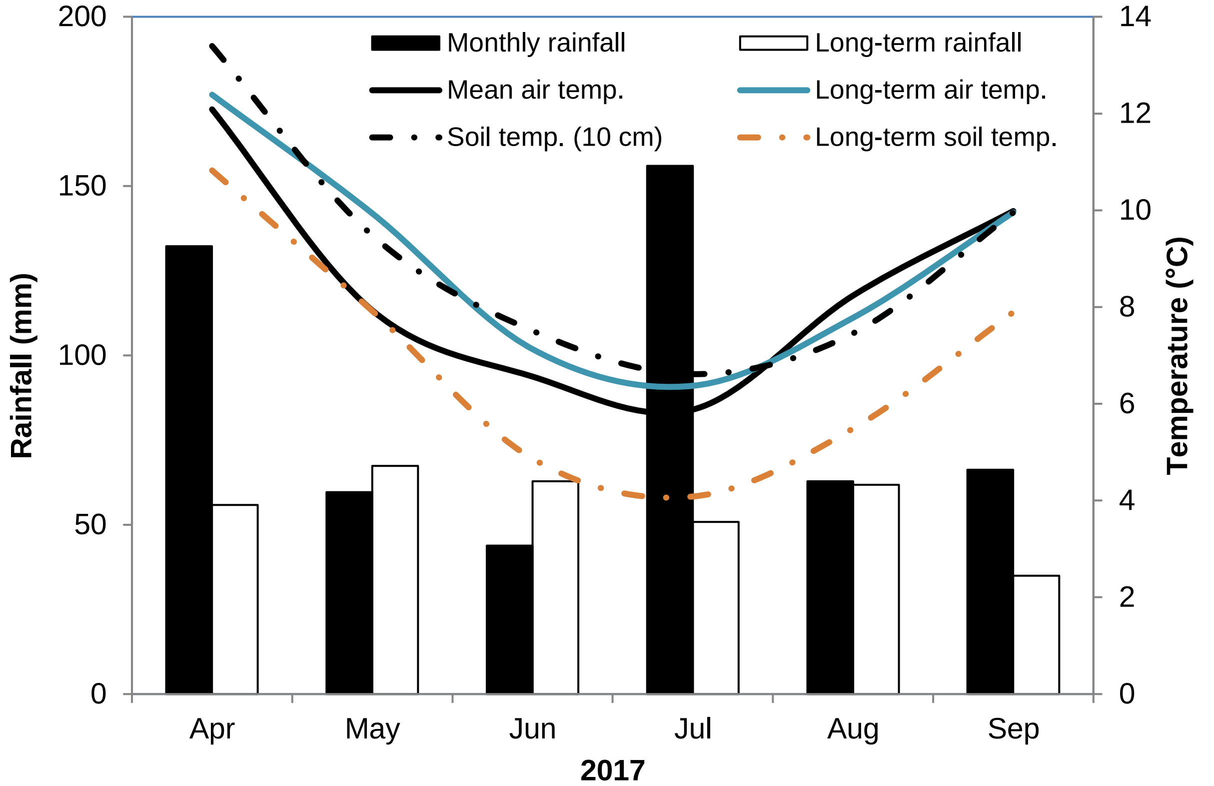

Figure 1. Mean LURDF monthly rainfall, air and soil (10 cm) temperature recorded over 2017 compared with long-term (LT; 2000-2016) means from NIWA's Broadfields climate station.

Due to differences in the target Cu concentration between the standard and Surflex fertilisers, herbage Cu concentrations for each fertiliser were adjusted accordingly according to equation 1.

$$Herbage - Cu_{adj} = (HerbCu_{fert} - HerbCu_{cont}) \times \frac{Cu_{target}}{Cu_{fert}} + HerbCu_{cont}$$

Equation 1.

where: *Herbage-Cu*$_{adj}$ is the adjusted pasture herbage-Cu concentration of the fertiliser treatment, $HerbCu_{fert}$ is the herbage-Cu concentration of the fertiliser treatment, $HerbCu_{cont}$ is the herbage-Cu concentration of the control (SSP-only), Cu_{fert} is the Cu concentration in the standard-Cu superphosphate mix or Surflex Cu-coated fertilisers, and Cu_{target} is the target Cu concentration for the Cu-fortified fertiliser.

For the standard-Cu fertiliser mix, this meant any net increase in herbage-Cu concentration was adjusted downwards by 17%, and for the Surflex-Cu fertiliser, adjusted upwards by 3%. Consequently, performance of the Surflex-Cu fertiliser treatment was actually better than the raw data results indicated (Table 3) and raised herbage-Cu concentrations compared with the control (SSP-only) by as much 11-13% over and above the increase from application of the standard-Cu mix (Table 4) and raised herbage-Cu concentrations from around 4-4.5 mg/kg DM to 5-5.5 mg/kg DM (Figure 2).

Table 3. Dry-matter production (DM), Cu and macro-element concentrations in pasture herbage for each harvest, and Cu uptake as a fraction of applied Cu.

Row Labels	DM	Cu	N	P	K	S	Cu
Harvest 1	**kg/ha**	**mg/kg**		**%**			**% uptake**
SSP	898	4.0 a	3.7	0.40	2.3	0.35	
SSP+$CuSO_4$	901	4.7 b	3.7	0.40	2.3	0.34	0.006%
Surflex-Cu_2O	819	5.1 c	3.8	0.39	2.4	0.35	0.007%
LSD (5%)	134	0.4	0.1	0.01	0.2	0.02	
Significance	ns	***	ns	ns	ns	ns	
Harvest 2							
SSP	685	4.1 a	3.0	0.38	2.5	0.36	
SSP+$CuSO_4$	666	4.9 ab	3.0	0.39	2.7	0.36	0.006%
Surflex-Cu_2O	647	5.4 b	2.9	0.38	2.6	0.34	0.009%
LSD (5%)	67	0.6	0.1	0.04	0.3	0.03	
Significance	ns	***	ns	ns	ns	ns	
Harvest 3							
SSP	1305	4.7 a	2.9	0.44	2.8	0.33	
SSP+$CuSO_4$	1348	5.3 b	3.0	0.45	2.9	0.34	0.011%
Surflex-Cu_2O	1271	5.5 b	2.9	0.44	2.9	0.35	0.014%
LSD (5%)	128	0.3	0.1	0.01	0.2	0.02	
Significance	ns	***	ns	ns	ns	*	

Means followed by a letter in common are not significantly different according to Duncan's multiple range test ($P < 0.05$).

Table 4. Adjusted percentage increase in copper pasture herbage content per unit area of Cu applied.

Treatment	Herbage-Cu% increase over control		
Days after application	*42*	*126*	*190*
SSP+$CuSO_4$	21%	27%	12%
Surflex-Cu_2O	34%	38%	18%

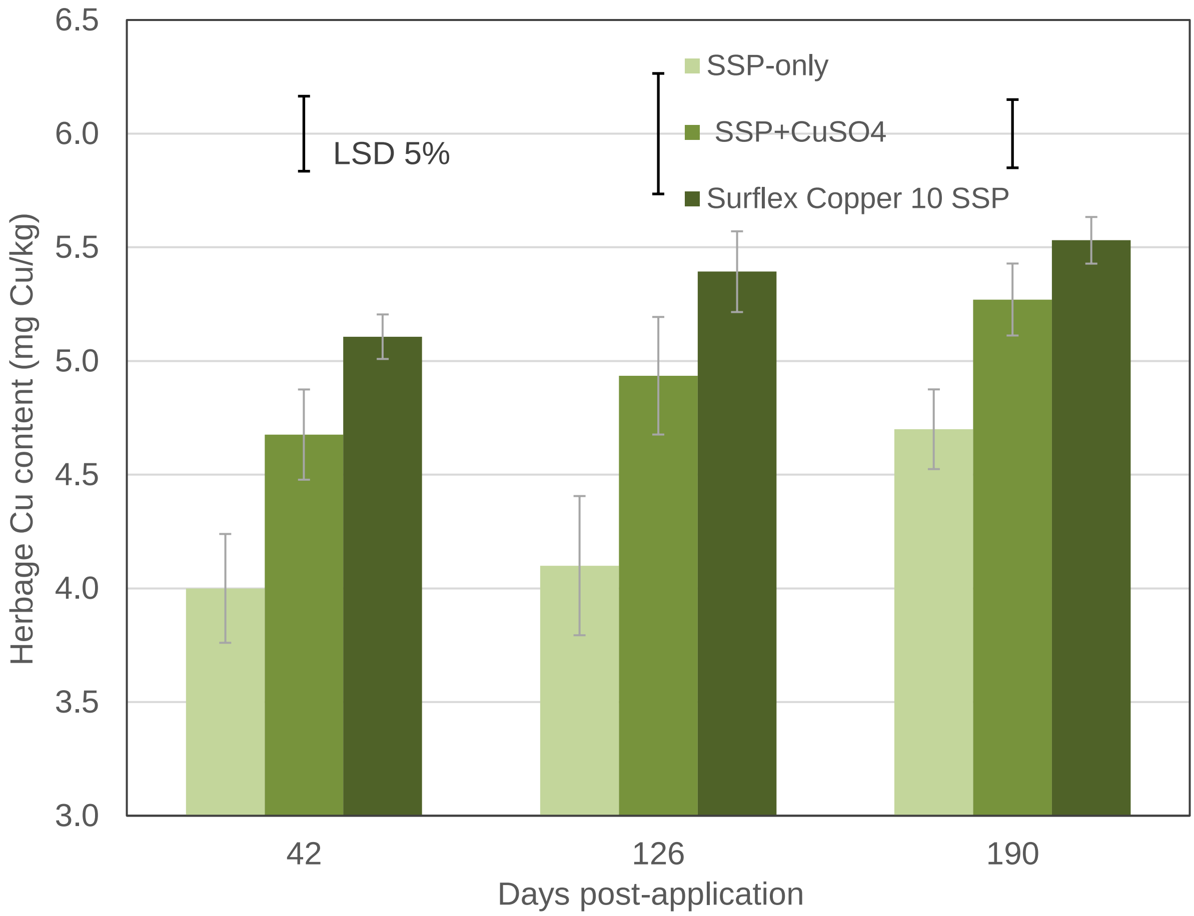

Figure 2. **Herbage-Cu concentrations for a Lincoln dairy pasture 42, 126 and 192 days after fertiliser application with a standard superphosphate (40 kg P/ha; 444 kg/ha), a standard-$CuSO_4$ superphosphate mix, and a Surflex Cu-coated superphosphate. Standard error bars (±1SE) and LSD (5%) bars shown.**

Copper sufficiency in pasture

Generally, herbage Cu concentrations <5 mg Cu/kg DM in sheep grazed pastures, and 8-10 mg Cu/kg DM for cattle and deer grazed pastures (Grace, 1994), are regarded as deficient for mixed pasture because of the need for Cu for the metabolism of ruminants and its important role in the nervous system, bone growth and immune functions (Morton *et al.*, 1999). However, only a small amount of the ingested Cu (5%) is available and most of the Cu (40-70%) is stored in the liver. Whilst Cu is rapidly transferred across the placenta and stored in the liver of the young, only very small amounts are secreted into milk, hence the need for adequate Cu in the feed intakes of young stock in particular.

In this trial, applying Cu at ~7 kg/ha only raised herbage-Cu levels into the marginal range (5-10 mg Cu/kg) at any stage of the trial. This may be because of the timing of the fertiliser application in mid-autumn, rather than at a time of more rapid pasture growth. Spring applications usually have a pattern of a swift rise in herbage-Cu concentrations in the first 30 days after application, and then a rapid decline after about 70 days (Figure 3). Results from this trial showed more modest increases in the first 42 days, but were maintained over a longer period (Figure 2). The reasons for this are unclear but may, as discussed earlier, be seasonal and/or related to the release and sorption of Cu by the soil. Nevertheless, Surflex-Cu treatments maintained an increase over the standard Cu-SSP treatment for the 192 days of the trial (Figure 2).

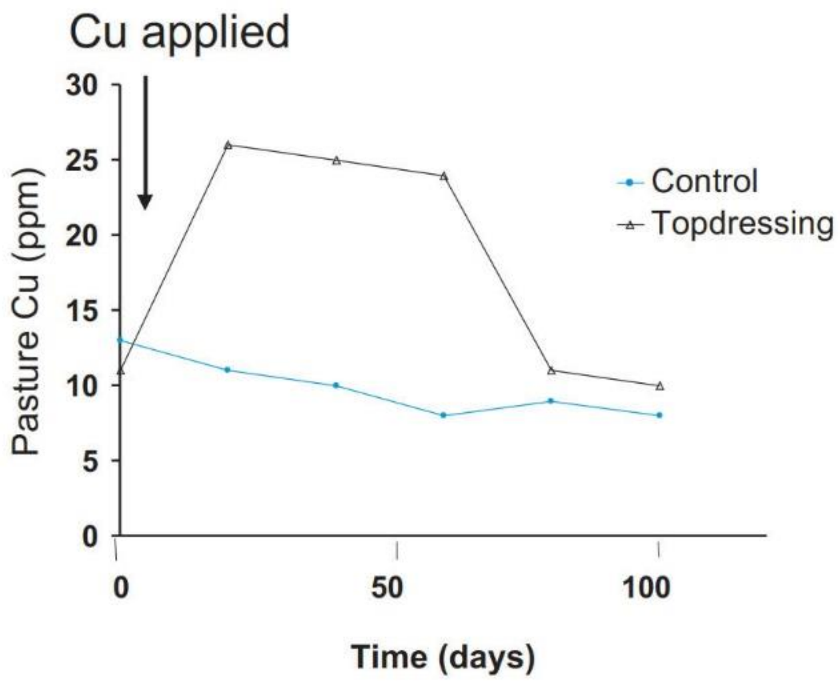

Figure 3. Rise in pasture herbage-Cu concentrations typically after Cu application at 6.4 kg Cu/ha. From Morton et al. (1999).

Other advantages of Surflex-technology

Although not the direct subject of this trial, the Surflex technology confers both handling, and health and safety advantages. Reduced dust, and a lack of need to ensure the trace element compound remains evenly distributed through the carrier fertiliser product offers several advantages over the *status quo* whilst the use of a lower solubility product (Cu_2O) in the Surflex coating may help increase availability for longer. However, further research on what mechanisms are responsible for this enhanced availability is needed.

Conclusions

The Surflex polymer-coating technology allowed more even distribution of Cu around the SSP fertiliser and significantly increased both pasture plant uptake of copper and use efficiency (18-38% above control Cu levels compared with 12-27% for standard treatment). Further work is required to understand the mode of action behind this increase, however, there is an assumption that the probable improvement in distribution of copper across the trial plots, and the use of cuprous oxide, which is insoluble in water, has some influence over the increased nutrient uptake efficiency.

In addition to the increased plant nutrient uptake, there were observed product quality improvements at the time of dispatch, and when applied by the trial operators. As well as coating the trace element to the SSP, the polymer also binds a large proportion of dust and fine particles. This has benefits both environmentally, for a potential reduction in product drift when aerially spread, and the health and safety of people handling and loading the product.

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References

Carey, P. L., McLaren, R. G. & Adams, J. A. 1996. Sorption of cupric, dichromate and arsenate ions in some New Zealand soilds. *Water, Air, and Soil Pollution,* **87,** 189-203.

Ellison, R. S. 2002. Major trace elements limiting livestock performance in New Zealand. *New Zealand Veterinary Journal,* **50,** 35-40.

Grace, N. D. 1994. *Managing Trace element deficiencies,* New Zealand Pastoral Agriculture Research Institute, Palmerston North.

Metherell, A. K. 1989. The cobalt enigma - some observations and strategies for Otago and Southland. *Proceedings of the New Zealand Grassland Association,* **50,** 101-108.

Morton, J., Grace, N. D. & O'Connor, M. B. (eds) 1999. *Use of trace elements in New Zealand pastoral farming,* New Zealand Fertiliser Manufacturers' Research Association, Hamilton.