SHORT COMMUNICATION

Coated KCl increases barley K uptake in two Alberta soils in a greenhouse experiment

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Zhang, M., Nyborg, M., Robertson, J. A. and Solberg, E. D. 1998. **Coated KCl increases barley K uptake in two Alberta soils in a greenhouse experiment**. Can. J. Soil Sci. **78**: 615–617. An experiment was conducted in the greenhouse on two K-responsive soils to determine the effectiveness of coated and non-coated KCl for barley (*Hordeum vulgare* L. 'Duke'). KCl granules, non-coated and coated with 2.5% and 3.5% polyurethane, were applied at 44 and 132 mg K per pot containing 2000 g of soil. Plant dry matter, K concentration and K uptake were determined on shoot samples taken 40 and 76 d after sowing. While dry matter was unaffected, coated KCl generally reduced plant K concentration and K uptake at 40 d and increased plant K concentration and K uptake at 76 d. We concluded the KCl coated with polyurethane can be more available to crops in K deficient soils.

Key words: Coated KCl, KCl, barley K, slow-release fertilizer

Zhang, M., Nyborg, M., Robertson, J. A. et Solberg, E. D. 1998. **Accroissement de l'absorption de K par l'orge par l'emploi de KCL enrobé : une expérience en serre sur deux sols de l'Alberta.** Can. J. Soil Sci. **78**: 615–617. Une expérience en serre a été réalisée sur deux sols carencés en K pour comparer l'efficacité du KCL enrobé et du KCL ordinaire pour la culture de l'orge (*Hordeum vulgare* L. 'Duke'). Des granules de KCL ordinaires et enrobés dans 2,5 et 3,5 % de polyuréthane ont été épandus à raison de 44 et de 132 mg K par pot de 2000 g de sol. Nous avons mesuré la production de matière sèche, la concentration et l'absorption de K dans les jeunes plantes 40 et 76 jours après le semis. Bien que l'enrobage n'ait pas eu d'effet sur la croissance (m.s.), il provoquait généralement une baisse de la concentration de K et de l'absorption de K dans les plantes au bout de 40 jours, mais un accroissement de ces deux propriétés à 76 jours. Il semble donc que l'enrobage de KCL dans le polyuréthane peut accroître sa disponibilité pour les cultures dans les sols carencés en K.

Mots clés: KCL enrobé, KCL ordinaire, engrais retard

Coated nitrogen and phosphate fertilizers often result in better crop growth than do non-coated fertilizers. For example, polymer coatings improved the effectiveness of urea for barley (Zhang 1994) and of monoammonium and diammonium phosphates for barley in greenhouse and field experiments (Nyborg et al. 1995). We hypothesized, therefore, that K fertilizers would also be more effective when coated. Polyolefin resin-coated KCl is available in Japan (Shoji and Gandeza 1992) but we are not aware of coated KCl being used for field crops in Canada and the United States.

Coated KCl could offer advantages over non-coated KCl by metering the release of KCl over time and thereby reducing fixation of K^+ (Bertsch and Thomas 1985), reducing salt concentrations near seedlings and roots, and reducing leaching. Our objective was to determine if coated KCl was more effective than non-coated KCl for barley growing on soils low in extractable K^+.

We chose soil samples from two fields where we had observed yield increases from added KCl over three years (Robertson et al 1985). Soil 1 was a Gleyed Gray Luvisol having a loam texture, organic matter of 36 g kg^{-1} and pH of 7.6. It had extractable K of 73 ± 8 mg kg^{-1}. Soil 2 was a Rego Humic Gleysol having a loam texture, organic matter of 103 g kg^{-1}, and pH of 7.5. Its extractable K was 48 ± 10 mg kg^{-1}. Penney (1985) reported that many of the potassium responsive sites in Alberta have similar characteristics of imperfect drainage, coarser texture (L–SL) and alkaline pH. Bulk soil samples were taken in April 1995 from the Ap horizons of the two sites.

We prepared coated KCl using a commercial polyurethane. KCl granules, 2–3 mm in diameter, were mixed with 0.5% (wt/wt) their mass of polyurethane in a Gustafson seed treater. After the polyurethane had hardened the process was repeated until the desired number of coatings had been applied. Two experimental products, KCl I with five coats (2.5% polyurethane) and KCl II with seven coats (3.5% polyurethane), were prepared. The release rates to distilled water (Fig. 1) were determined on duplicate samples by placing 1.5 g of coated KCl in 500 mL of distilled water at 23°C. The mixture was not stirred except briefly at the time of removing 2 mL of solution for determining KCl concentration.

A completely randomized experiment with three replicates was conducted in the greenhouse. 2000 g of soil were placed in plastic pots (15 cm diameter, 16 cm depth) having no drain holes. Prior to potting, solutions of ammonium nitrate (132 mg N/pot), monoammonium phosphate (40 mg P/pot) and sodium sulfate (26 mg S per pot) were mixed into

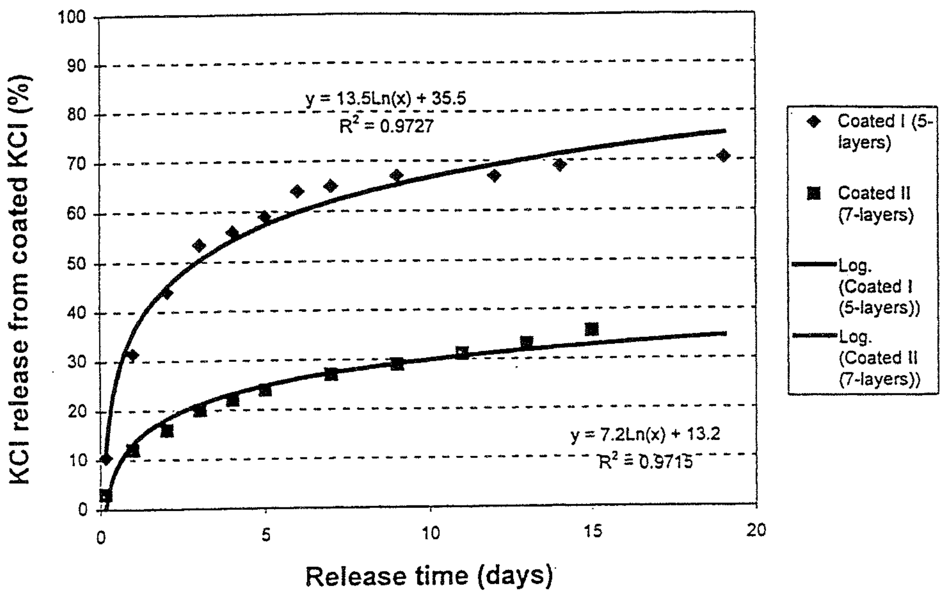

Fig. 1. Release of KCl from Coated KCl I and II in water at 23°C.

the soil. Another nitrogen application (132 mg N/pot) was made 14 d after sowing. The experimental treatments were: (1) control, no K; (2) non-coated KCl at 44 mg K/pot; (3) coated KCl I at 44 mg K per pot; (4) coated KCl II at 44 K mg per pot; (5) non-coated KCl at 132 mg K per pot; (6) coated KCl I at 132 mg K per pot; and (7) coated KCl II at 132 mg K per pot. The KCl, either four granules or 12 granules, was placed in a row 2.5 cm below the soil surface. Twelve barley (cv. Duke) seeds were placed in a row exactly above the fertilizer row and 1.0 cm below the soil surface. Following emergence, about 1 wk after sowing, plants were thinned to eight per pot. Demineralized water was added to the pots by weight to maintain moisture between 70 and 100% of field capacity. The experiment was conducted from 2 June to 17 August 1995. No supplemental light was used and the greenhouse temperature was 23 ± 5°C. Aboveground biomass was harvested at 40 or 76 d after sowing, dried at 65°C and weighed. The samples were ground and total K content was determined (Richards 1993). Biomass, plant K concentration, and K uptake were analyzed by ANOVA, and the least significant differences (LSD) were calculated at the 5% level. In the following discussion we declared significance when the orthogonal contrast probability was <0.05. Because the contrasts were calculated over two application rates (or three coatings), we used $LSD_{0.05}$ to determine whether the significance occurred at both rates (or for all three coatings).

At 40 d barley dry matter was not significantly different among treatments on either soil ($P > 0.05$, Table 1). There were, however, differences in plant K concentration and K uptake. K concentration was significantly lower for coated than non-coated KCl (contrasts <0.05) and, except for the high K application on soil 2 (LSD ≠ 0.05), lower for KCl II than for KCl I. K uptake on soil 1 was significantly lower for KCl II than for KCl I and non-coated KCl at both applications (contrasts < 0.05). On soil 2 there was no difference between coatings in K uptake at the low application (LSD ≠ 0.05), but at the high application both coated products resulted in lower uptake than for non-coated (LSD). The low application of all products on both soils resulted in lower K concentrations than for the high application (contrasts < 0.05), and lower K uptakes, particularly on soil 1 (contrasts < 0.05).

At 76 d, as at 40 d, there were no significant differences in dry matter production on either soil ($P > 0.05$, Table 1). For soil 1, compared with the non-coated KCl, KCl I resulted in a greater K concentration at the low application and both products did so at the high application (LSD). Likewise, at the high application, K uptake was greater for both KCl I and KCl II than for non-coated KCl (LSD). For soil 2, both K concentrations and K uptake were significantly greater for KCl I than for non-coated KCl (contrast < 0.05). Further, both K concentration and K uptake were significantly greater for KCl I than for KCl II (contrast <0.05).

These concentrations and uptake data at 40 d imply that slower release of K from coated KCl, especially from KCl II, resulted in lower K concentration in the soil solution and hence lower availability of K to plants in the earlier stages of growth. By contrast, the data at 76 d provide evidence that slowing the release of K^+ to the soil solution resulted in its greater availability to the plant at later stages of growth.

This experiment was conducted using pots without drain holes so avoidance of leaching could not account for any advantage of coated KCl. Further, the KCl was not in direct contact with the barley seeds and thus we believe that the benefit of coating KCl was not due to reducing harmful salt concentrations. Regarding the possibility of fixation of K^+, we have limited preliminary unpublished data to suggest that soil 1 contains significant amounts of vermiculite in the silt and clay–sized fractions and for a large portion of the cation exchange sites to be K^+ fixing sites.

We have shown that coated KCl can delay release of K^+ to the soil solution and, thus, to increase K concentration

Table 1. Barley dry matter, K concentration, and K uptake from coated and non-coated KCl fertilizer at 40 and 76 d after sowing

Treatment		Soil 1			Soil 2		
Coating	mg K/pot	Dry matter (g/pot)	Plant K (mg/g)	K uptake (mg/pot)	Dry matter (g/pot)	Plant K (mg/g)	K uptake (mg/pot)
				Immature (40 d)			
None	None	2.97	11.8	35	3.78	33.1	125
None	44	2.85	15.8	45	3.48	37.2	129
Coat I	44	3.03	14.2	43	3.53	36.9	130
Coat II	44	2.76	11.6	32	3.67	35.0	129
None	132	2.91	23.7	68	3.72	42.1	157
Coat I	132	3.29	21.5	70	3.52	37.6	132
Coat II	132	3.21	14.6	47	3.64	37.4	136
Prob		0.1712	0.0001	0.0001	0.8636	0.002	0.1567
$LSD_{0.05}$		0.45	2.5	5	0.54	2.9	21
Contrasts[z]							
Non-coat vs. coat I		-0.0843	0.0407	-0.9465	0.6791	0.0243	0.1097
Non-coat vs. coat II		-0.4890	0.0001	0.0001	-0.7489	0.0028	0.1456
Coat I vs. coat II		0.2415	0.0001	0.0001	-0.4409	0.2413	-0.8588
Rate 44 vs. rate 132		-0.0495	-0.0001	-0.0001	-0.6447	-0.0037	-0.0440
				Mature (76 d)			
None	None	8.72	8.3	72	11.85	15.8	194
None	44	9.08	9.4	85	12.12	16.2	196
Coat I	44	9.42	9.6	90	12.19	17.6	215
Coat II	44	9.28	9.4	88	11.92	16.8	201
None	132	9.42	11.5	109	11.93	17.6	210
Coat I	132	9.56	12.7	121	11.72	19.0	223
Coat II	132	9.17	13.2	121	12.13	17.2	209
Prob		0.5336	0.0001	0.0001	0.1939	0.0603	0.1336
LSD_{05}		0.91	1.0	12	0.4	1.9	21
Contrasts[z]							
Non-coat vs. coat I		-0.4391	-0.0615	-0.0471	0.5772	-0.0426	-0.0433
Non-coat vs. coat II		0.9303	-0.0219	-0.0847	0.9682	-0.8355	-0.8101
Coat I vs. coat II		0.3909	-0.5941	0.7527	-0.5836	0.0500	0.0537
Rate 44 vs. rate 132		-0.6247	-0.0001	-0.0001	0.1674	-0.0518	-0.0874

[z]A negative sign preceding the contrast probabilities indicates that the second variable in the comparison is larger than the first variable.

and uptake in the late stages of barley growth. Further work is required to determine whether other coat thicknesses, or a mixture of granules with different coat thicknesses, would provide more effective release rates of K^+. There are estimated to be 1.8 million ha of K-responsive soils in the Prairie Provinces of which 1.0 million ha are in Alberta (Doyle and Cowell 1993). We conclude that coated KCl could be of practical use in this area.

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