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

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Abstract

An experiment was conducted on two soils in the greenhouse to determine the efficiency of coated KCl fertilizer for barley (Hordeum vulgare L. cv Duke). Thin and thickly polymer-coated KCl and non-coated KCl fertilizers were applied at 25 and 75 kg K/ha on two K deficient Alberta soils. Plant dry matter and K content were determined from the shoot samples taken at 40 and 76 days after seeding. The coated KCl resulted in a higher barley K uptake in comparison with the non-coated KCl. We concluded that coating KCl fertilizer with polymers can improve its availability to crops in K deficient soils.

Key words: Coated KCl, KCl, barley K uptake.

Availability of applied potassium (K) fertilizers in soil is reduced through leaching and clay fixation (Bertsch and Thomas, 1985). In Western Canada, there are

approximately 1.8×10^6 ha K deficient soils, and more than 50% of them are in Alberta (Doyle and Cowell, 1993). In Alberta, K deficient soils appear to be light to medium textured, high pH, carbonated with imperfectly to poor drainage (Penney, 1985). Coating fertilizers with polymers improves nitrogen and phosphorus fertilizer availability to crops (Zhang, 1994, Nyborg et al., 1995). There is commercial coated potassium chloride (KCl) in Japan (Shoji and Gandeza, 1992), however, there are no reports on efficiency of coated KCl fertilizer to crops in Canada. The objective was to determine if coated KCl promoted barley K uptake in two K deficient Alberta soils.

Two soil samples were taken from areas where barley is K deficient. The two soils (Soil 1 and Soil 2) appear in Table 1. The experiment was conducted in the greenhouse at 23±5°C from June 2, to August 17, 1995. The treatments were: 1) Nil; 2) Non-coated KCl at 25 kg K/ha; 3) Coated KCl I (5-layers) at 25 kg K/ha; 4) Coated KCl II (7-layers) at 25 kg K/ha; 5) Non-coated KCl at 75 kg K/ha; 6) Coated KCl I at 75 kg K/ha; and 7) Coated KCl II at 75 kg K/ha. There were three replicates. KCl fertilizer granules were sieved into 2 to 3 mm in size. Polymer-coated KCl fertilizers were prepared in the laboratory of the University of Alberta. The release characteristics of Coated KCl I and Coated KCl II in water at 23°C was shown in Figure 1. Two kg of soil was placed in a pot (15-cm diameter and 16-cm depth). Prior to seeding, solutions of ammonium nitrate at 100 kg N/ha, monoammonium phosphate at 30 kg P/ha and sodium sulfate at 20 kg S/ha were mixed into soil. Another 100 kg N/ha was added 14 days after seeding. Non-coated or coated KCl was placed in a row 2.5 cm below the soil surface.

There were 4 and 12 KCl granules per pot for 25 and 75 kg K/ha, respectively. Twelve barley (cv. Duke) seeds were placed in a row 1.5 cm exactly above the fertilizer row and 1 cm below the soil surface. After germination (about a week after seeding), eight seedlings were kept per pot. There was no supplemental light during the experiment. Shoot samples were taken at 40 and 76 days after seeding, dried at 65°C and weighed. The samples were then ground, digested and determined for total K content (Richards, 1993).

The experiment was a complete randomized design. The data were analyzed with ANOVA followed by Least Significant Difference (LSD) at 5% level.

At 40 days, barley dry matter was similar among the treatments in both soils (Fig. 2a), but the K content was higher with non-coated KCl and Coated KCl I than with Coated KCl II at both rates of application (Fig. 2b). The K uptake, however, was higher with non-coated KCl and Coated KCl I than with Coated KCl II at 25 and 75 kg K/ha in Soil 1, but higher with non-coated KCl than with Coated KCl I and Coated KCl II at 75 kg k/ha in Soil 2 (Fig. 2c).

In the second sampling (76 days), however, coating increased plant dry matter, K content and K uptake in both soils (Table 2). In Soil 1, at 25 kg K/ha, the dry matter of Coated KCl I and Coated KCl II tended to be higher than the non-coated KCl. But when the rate was increased to 75 kg K/ha, only Coated KCl I had slightly higher dry matter than the non-coated KCl treatment. The K content of the shoots, on the other hand, was higher with only Coated KCl I at 25 kg K/ha and with both Coated KCl I and Coated KCl II at 75 kg K/ha as compared to the non-coated KCl treatments. The K uptake of barley

from Coated KCl I and Coated KCl II tended to be higher than the non-coated KCl at 25 kg K/ha. But at 75 kg K/ha, the K uptake was significantly higher with the coated KCl than non-coated KCl treatments. In Soil 2, the dry matter tended to be higher with coated KCl than with the non-coated KCl at 25 kg K/ha, but was similar among the treatments when the rate was 75 kg K/ha (Table 2). The K content and K uptake from the Coated KCl I was significantly higher than non-coated KCl only at 25 kg K/ha. Comparing the two soils, the benefit of coating to plant K uptake showed at 75 kg K/ha in Soil 1, but at 25 kg K/ha in Soil 2. Nevertheless, coating increased barley K uptake.

Fertilizer K availability to plant is reduced by leaching and fixation (Bertsch and Thomas, 1985). However, in our experiment, coating decreased solubility of KCl in soil, therefore, reducing the opportunities for losses. Even though the soils used in our experiments in the greenhouse were K deficient, coated KCl applied in soils resulted in higher K uptake by barley in both soils compared to the non-coated KCl. We concluded that coating improved plant K uptake in K deficient soils.

References

Bertsch, P. M. and Thomas, G. W. 1985. Potassium status of temperate region soils. In: Potassium in Agriculture, R.D. Munson, (ed.) pp131-162. ASA-CSSA-SSSA Madison, Wisconsin, US.

Doyle, P. J. and Cowell, L.E. 1993. Potassium. In: Impact of Macronutrients on Crop Responses and Environmental Sustainability on the Canadian Prairies, D.A. Rennie, C.A. Campbell and T.L. Roberts (eds.). pp. 171-201. Canadian Society of Soil Science, Ottawa, Canada .

Nyborg, M. Solberg, E.D. and Pauly, D.G. 1995. Coating of phosphorus fertilizers with polymers increases crop yield and fertilizer efficiency. Better Crops With Plant Food. 79 (1995): No.3 pp8-9.

Penney, D.C. 1985. Potassium fertilizer application in crop production. Agdex 542-9 (June, 1985), Alberta Agriculture, 7000-113 Street, Edmonton, Alberta, p 4.

Richards, J.E. 1993. Chemical characterization of plant tissue. Soil Sampling and Methods of Analysis. M.R. Carter (ed.), Canadian Society of Soil Science pp 115-139. Lewis Publisher.

Shoji, S. and Gandeza, A.T. 1992. Controlled Release Fertilizers with Polyolefin Resin. Coating. Konno Printing Co. Sendai, Japan, p 92.

Zhang, Mingchu. 1994. Polymer-coated urea. Ph.D. thesis. Department of Soil Science, University of Alberta, Edmonton Alberta, Canada

Table 1. Some characteristics of soils (0-15 cm).

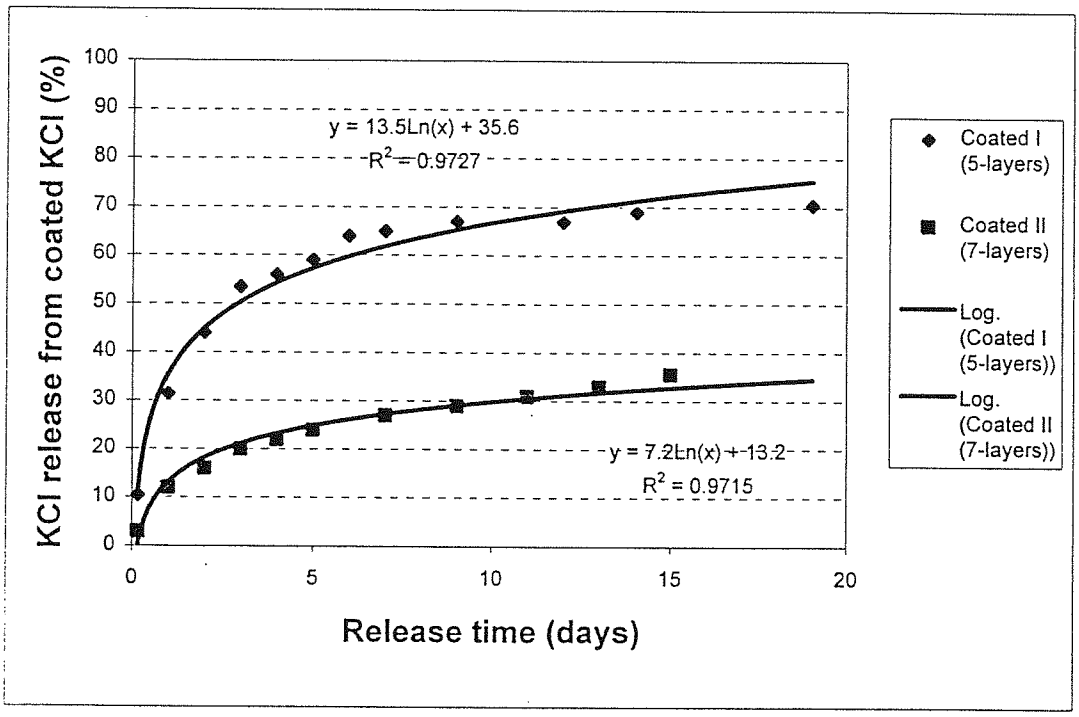
Soil name	Soil classification	Legal location	Texture	Organic matter %	pH (1:2)	Extractable K (mg kg^{-1})
Soil 1	Gleyed Gray Luvisol	NW14-61-9-W4	Loam	3.6	7.6	73±8.4
Soil 2	Rego Humic Gleysol	NW9-62-2-W5	Loam	10.3	7.5	48±9.8

Table 2. Barley dry matter, K content and K uptake from coated and non-coated KCl fertilizers.

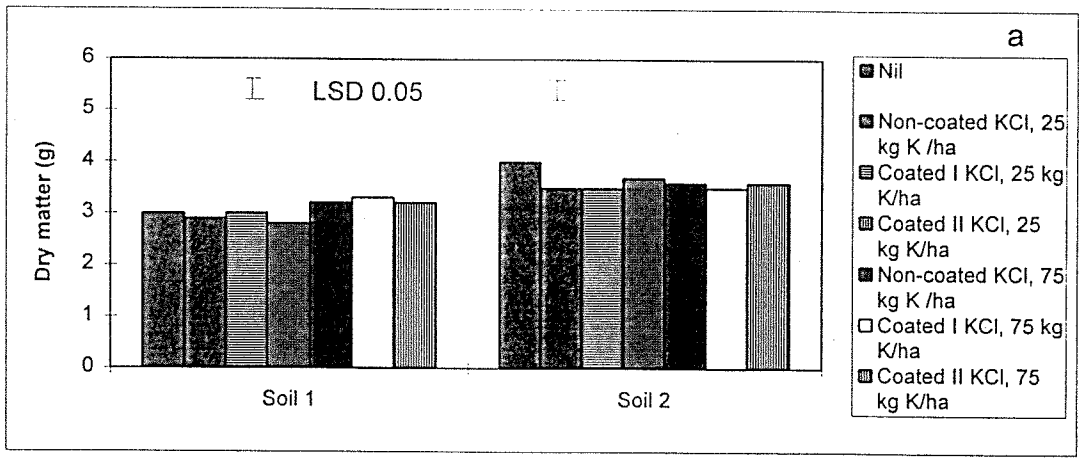
Treatment	Soil 1				Soil 2			
	Dry matter	K content	K uptake	K uptake from fertilizer	Dry matter	K content	K uptake	K uptake from fertilizer
	g	%	mg	%	g	%	mg	%
Nil	8.72	0.83	72		12.30	1.58	194	
Non-coated KCl, 25 kg K/ha	9.08	0.94	85	28	11.61	1.63	189	6
Coated KCl I, 25 kg K/ha	9.42	0.96	90	40	12.19	1.76	215	48
Coated KCl II , 25 kg k/ha	9.28	0.94	87	34	11.92	1.68	201	20
Non-coated KCl, 75 kg K/ha	9.42	1.15	109	27	11.93	1.76	210	12
Coated KCl I, 75 kg K/ha	9.56	1.27	121	37	12.35	1.83	226	24
Coated KCl II, 75 kg k/ha	9.17	1.32	121	37	12.13	1.72	208	13
LSD 0.05	0.56	0.12	10	17	0.75	0.12	17	24

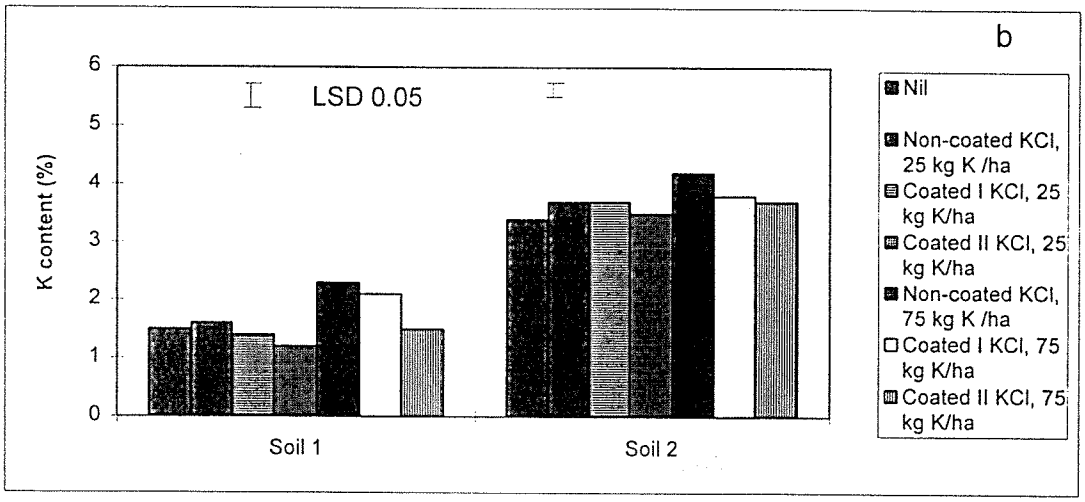
Fig. 1. Release of KCl from Coated KCl I and II in water at 23°C.

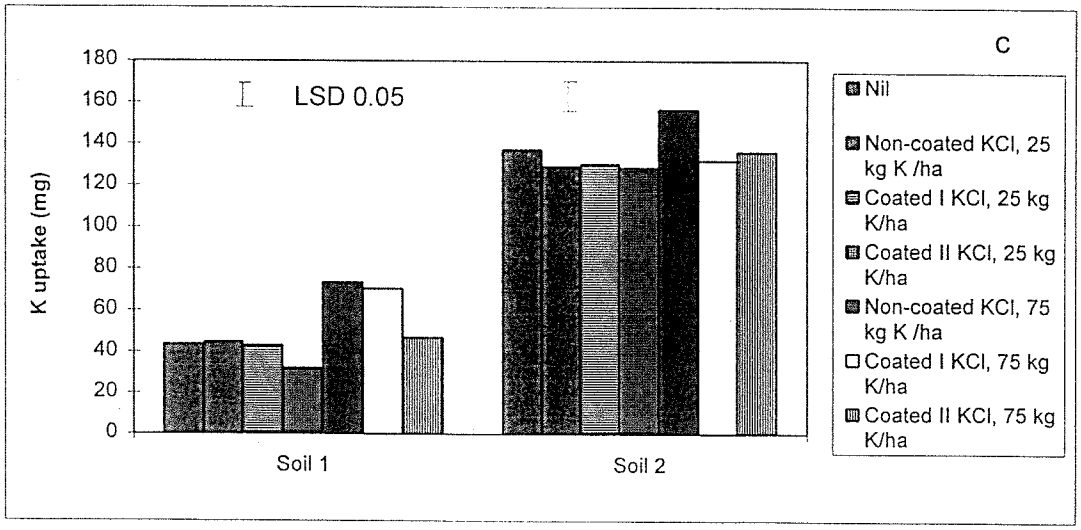
Fig. 2. Barley dry matter (a), shoot K content (b) and K uptake from Soil 1 and 2 at 40 days after seeding.


KCl release from coated KCl (%)
100
90
80
70
60
50
40
30
20
10
0
y = 13.5Ln(x) + 35.6
R² = 0.9727
y = 7.2Ln(x) + 13.2
R² = 0.9715
0
5
10
15
20
Release time (days)
Coated I (5-layers)
Coated II (7-layers)
Log. (Coated I (5-layers))
Log. (Coated II (7-layers))

F-8


a
Dry matter (g)
6
5
4
3
2
1
0
LSD 0.05
Soil 1
Soil 2
Nil
Non-coated KCl, 25 kg K /ha
Coated I KCl, 25 kg K/ha
Coated II KCl, 25 kg K/ha
Non-coated KCl, 75 kg K /ha
Coated I KCl, 75 kg K/ha
Coated II KCl, 75 kg K/ha


b
K content (%)
6
5
4
3
2
1
0
LSD 0.05
Soil 1
Soil 2
Nil
Non-coated KCl, 25 kg K /ha
Coated I KCl, 25 kg K/ha
Coated II KCl, 25 kg K/ha
Non-coated KCl, 75 kg K /ha
Coated I KCl, 75 kg K/ha
Coated II KCl, 75 kg K/ha


c
K uptake (mg)
180
160
140
120
100
80
60
40
20
0
LSD 0.05
Soil 1
Soil 2
Nil
Non-coated KCl, 25 kg K /ha
Coated I KCl, 25 kg K/ha
Coated II KCl, 25 kg K/ha
Non-coated KCl, 75 kg K /ha
Coated I KCl, 75 kg K/ha
Coated II KCl, 75 kg K/ha