# Summary of the Research Project of

# "Agronomy Aspects of the Coated Potassium Chloride Fertilizers"

**Mingchu Chang, M Nyborg**

In western Canada, approximately 1.8 million hectares of cultivated soils are deficient in potassium so that KCl fertilizer is needed for good yield. But efficiency of KCl fertilizers is hindered by salt injury to seeds/seedlings when applied in the seedrow or through low efficiency in K deficient soils. Coating soluble fertilizers (e.g. urea) with polymers can result in timely metering of nutrients to better meet plant requirements. There is coated KCl reported in Japan but none in Canada. The objectives of the research were to determine if coating improves seedling growth when coated KCl fertilizer is applied in the seedrow, and to determine if coating KCl fertilizer can improve KCl fertilizer efficiency to plants grown in K deficient soils in western Canada.

We have prepared two coated KCl fertilizers with 2.5% and 3.5% coating thicknesses, respectively. The release rate of the fertilizers were approximately one month and 6 months in water at 23°C, respectively. We used these two coated KCl fertilizers to conduct four greenhouse experiments and one field experiment. Of those, three greenhouse experiments and one field experiment were used to determine seed germination and seedling dry matter production of canola, barley and wheat as affected by seed placed coated KCl fertilizers. The other greenhouse experiment was to determine the efficiency of coated KCl to barley. In this experiment, we conducted a survey on the effect of KCl on physiologic leaf spot of barley.

From those five experiments, we have found that coated KCl applied in the seedrow had a less adverse effect on seed germination and seedling growth compared to non-coated KCl. This was more pronounced with canola than barley or wheat. We also found that coated KCl fertilizer delayed the release of $K^+$ to the soil solution and thus increased the K concentration and uptake in the late stages of barley growth. Therefore, coated KCl fertilizer can be of practical use in high potassium fixation soils. In addition, we found that KCl depresses physiologic leaf spot of barley.

By completion of the research project, we have submitted two papers to the Canadian Journal of Soil Science, one paper to the Canadian Journal of Plant Science. Those papers are listed and attached to this summary.

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16 June 1998

| Title | Authors | Journal | Status | Date of Resubmission After the Editors Review |
|---|---|---|---|---|
| Seed germination and seedling dry matter production of canola, barley and wheat as affected by seed placed KCl and polymer coated KCl | Minchu Zhang<br>M. Nyborg<br>E.D. Solberg | Canadian Journal of Soil Science | Accepted | 13 May 1998 |
| Coated KCl increases K uptake in two Alberta soils in a greenhouse experiment | Minchu Zhang<br>M. Nyborg<br>E.D. Solberg | Canadian Journal of Soil Science | Accepted | 17 April 1998 |
| KCl depresses physiologic leaf sot of Barley (Hordeum vulgare L. cv Duke) | Minchu Zhang<br>M. Nyborg<br>E.D. Solberg | Canadian Journal of Plant Science | In press | 29 February 1998 |

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Title: **KCl Depresses Physiologic Leaf Spot of Barley (*Hordeum vulgare* L. cv. Duke)**

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# KCl Depresses Physiologic Leaf Spot of Barley (*Hordeum vulgare* L. cv. Duke)

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**Abstract**

Physiologic leaf spot was observed on barley in the greenhouse either with or without KCl and $K_2SO_4$ fertilization. The area covered by the leaf spot was 8.1% without fertilization, with $K_2SO_4$ the area was up to 13.7% but KCl had only 0.3 and 3.1% for 75 and 25 kg K/ha, respectively. Suppression of the leaf spotting was not due to $K^+$ or $SO_4^{2-}$, but $Cl^-$.

Key words: KCl fertilization, Physiologic leaf spot

Researchers have reported that plant diseases were suppressed by KCl fertilizer. They often attributed this to the presence of the $Cl^-$ because with the additions of $NH_4Cl$ or KCl, the infection by net blotch in barley was reduced (Beaton, 1980). The $Cl^-$ component of KCl and other sources supplying $Cl^-$ to plants has been shown to suppress take-all, stripe rust, glume blotch, halo spot, net blotch and common root rot (Beaton and Sekhon, 1985, Huber and Arny, 1985, Goos, 1989). Mohr et al. (1995) reported chloride reduced common root rot but not spot blotch for barley. ~~However, there is no report on depression of physiologic leaf spot on barley by KCl fertilizer.~~ Engle (1995) reported that plant chloride nutrition had a profound effect on physiological leaf spot in selected winter wheat cultivars.

Physiologic leaf spots are found both in greenhouse and fields (Mathre, 1982). They occur in the leaves of barley in the conditions of high temperature and high humidity. The actual cause so far is not very clear (Clark et al., 1979).

From June to September of 1995, we conducted the experiments in the greenhouse (23±5°C) of the University of Alberta to study the release rate of polymer-coated KCl, and barley (cv. Duke) K uptake from non-coated and polymer-coated KCl, and $K_2SO_4$ applied in soil. During the experiment, we observed that the degree of physiologic leaf spots in barley was less in the KCl treatments than in the $K_2SO_4$ treatments.

The treatments were 1) nil, 2) KCl , 3) coated KCl I, 4) coated KCl II, 5) $K_2SO_4$, 6) coated $K_2SO_4$ I, and 7) coated $K_2SO_4$ II. There were two rates of application, 25 and 75 kg K/ha for each of the KCl treatments, but only one rate for the $K_2SO_4$ treatments. Polymer-coated K fertilizers were prepared by encapsulating fertilizer particles with a polymer so that the K was released in a timely manner. Coated I has a thinner coating and a faster release rate than coated II. Each treatment was replicated three times. Eight barley seeds were grown in a Dark Gray Chernozemic soil with water content of 90% field capacity. Nitrogen, phosphorus, and sulfur were also applied into soil at a rate of 200, 30, and 20 kg /ha, respectively. The experiment started at June 2, 1995. The physiologic leaf spots were observed in later July and were measured on August 14, 1995 at the ~~growth stage~~ of heading stage. Percent leaf area covered by the brown spots was assessed from the leaf second ~~to the~~ and flag ~~leaf because the leaf was seriously spotted~~. Four leaves were measured from each replicate. The data were then analyzed by ANOVA followed with the test of LSD (Least Significant Difference) at 5% level.

The percent brown-spot area was different ($p = 0.01$) among the treatments (Table 1). Pots without KCl or $K_2SO_4$ had 8.1% of brown-spots (Table 2). Pots with KCl addition had less brown spots compared to the pots with $K_2SO_4$ application or nil. For example, there were 3.1% spot area in non-coated KCl at 25 kg K/ha treatment, but 7.6% with the non-coated $K_2SO_4$ treatment at same rate. Compared among the KCl treatments, the higher the application rate, the less area of the spots. The average area for the KCl at 25 kg K/ha was 3.9% in contrast with 1.1% of KCl at 75 kg K/ha. Coated I had a thinner coating and it released the encapsulated KCl faster than did Coated II. Under such circumstance, Coated II tended to get more infections than Coated I, probably due to less KCl available to plant roots. ~~Similar case occurred~~ Similarly with $K_2SO_4$, in which the Coated II had higher spot area than the Coated I and non-coated $K_2SO_4$.

Powelson and Jackson (1980) concluded that $Cl^-$-containing materials reduced take-all root rot in wheat. Other researchers (Cunfer, 1980, Temiz, 1976) showed that increasing $K^+$ suppressed wheat glume blotch and leaf blotch. In our experiment, we used KCl and $K_2SO_4$ fertilizers. Even though coated $K_2SO_4$ tended to have a higher spot area than non-coated $K_2SO_4$, comparing the percent leaf area covered by the spots over all from KCl and $K_2SO_4$ treatments, the $Cl^-$ was more likely playing a role in reducing the physiologic leaf spot.

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Table 1. ANOVA for the percent leaf area covered by physiologic leaf spots.

| Source | Df | MSE | F value | Tabulated F values | |
|---|---|---|---|---|---|
| | | | | 0.05 | 0.01 |
| Treatment | 9 | 65.4 | 7.8 | 2.4 | 3.6 |
| Error | 20 | 8.4 | | | |

Table 2. Percent leaf area covered by physiologic leaf spots.

| Treatment | Coating | Rate of K application | Leaf area covered by the spots |
|---|---|---|---|
| | | kg K/ha | % |
| Nil | | 0 | 8.1 |
| $K_2SO_4$ | no | 25 | 7.6 |
| $K_2SO_4$ | coated I[z] | 25 | 10.7 |
| $K_2SO_4$ | coated II[y] | 25 | 13.7 |
| KCl | no | 25 | 3.1 |
| KCl | coated I | 25 | 1.1 |
| KCl | coated II | 25 | 6.9 |
| KCl | no | 75 | 0.3 |
| KCl | coated I | 75 | 1.2 |
| KCl | coated II | 75 | 1.9 |
| LSD 0.05 | | | 4.1 |

[z]Thin coating.

[y]Thick coating.

13 May.

# Seed germination and seedling dry matter production of canola, barley and wheat as affected by seed-placed KCl and polymer-coated KCl

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**Abstract**

Seed-placed KCl often adversely affects seed germination and seedling growth because of the high salt index of the material. By coating KCl granules the adverse effect of the KCl can be reduced. Two greenhouse experiments with canola, barley and wheat, and one experiment in the field with barley were conducted to determine if normally adverse levels of seed-placed KCl fertilizer could be reduced when polymer coated KCl is used. The results show that the number of germinated seeds and seedling dry matter were higher with the seed-placed coated KCl than the seed-placed regular non-coated KCl.

**Key words**: KCl fertilizer, polymer-coated KCl, germination, seedling dry matter.

In western Canada, approximately $1.8\times10^6$ ha of cultivated soils are deficient in potassium (K) so that KCl fertilizer is needed for good yields (Doyle and Cowell, 1993). Malhi et al. (1993) conducted field experiments with KCl fertilizer (12.5 and 25 kg K $ha^{-1}$, a low rate) for barley and rape seed in different areas of central Alberta. The results showed much larger yield increases from mature crops when the fertilizer had been seed placed rather than side banded. In Alberta, Penney (1985) recommended 75 and 60 kg K $ha^{-1}$ in highly K-deficient soils for cereal crops and canola, respectively, and the KCl should be banded or broadcast to avoid seedling injury when the rate of application was higher than 34 kg K $ha^{-1}$ for cereal crops and 17 kg K $ha^{-1}$ for canola.

There are many reports on polymer-coated nitrogen fertilizers (Zhang, 1994). Most recently, Nyborg et al. (1995) found that coated monoammonium phosphate improved barley P uptake. There were polyolefin coated KCl fertilizers reported in Japan (Shoji and Gandeza, 1992), but research on coated KCl has not been reported in Canada. The objective was to evaluate a slow-release coated KCl fertilizer; and to find if the coated KCl, compared to non-coated KCl, will result in better growth with seed-placed KCl for several crops.

Four experiments were conducted. One of the experiments was in the laboratory. Two were in the greenhouse and one was in the field at the Ellerslie Research Station. In the four experiments, there were three sources of KCl fertilizers, non-coated KCl, Coated I (5-layers of polymer) and Coated II (7 layers of polymer).

In the laboratory experiment, KCl fertilizer had a content of 51.5% K and the mesh was 2 to 3 mm. The KCl granules were coated with a polymer one layer at a time, through a Gustafson seed treater (27-cm dia. by 32-cm depth) in a laboratory at the University of Alberta. Each layer was approximately 0.3% of the KCl granulate mass. The coated KCl used was the Coated I and Coated II and the rate released was determined daily for 19 days in water at 23°C. There were three water solutions, each consisting of 20 granules of non-coated KCl, Coated I and Coated II, respectively. Each day, estimates were made of soluble KCl by determination of electrical conductivity in the solutions (YSI conductivity bridge, Model 31, Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, US).

In the two greenhouse experiments in 1997, a Black Chernozem soil with a pH of 7.5, 8.5% organic matter, field capacity (F.C.) of 32.6%, and three crops, canola (*Brassica napus* cv.

Legacy), barley (*Hordeum vulgare* L. cv. Harrington) and wheat (*Triticum aestivum* L. cv. Cutler) were used. The rate of K application was 0, 40, 80 and 160 kg K $ha^{-1}$. Eight seeds about 1.6 cm apart in a row were placed in 2 kg soil held in a pot (17-cm diameter, 12-cm depth) at a depth of 1 cm. The KCl fertilizer granules were placed side by side with the seeds. There were three sources of KCl fertilizers: non-coated KCl, Coated I and Coated II. The number of granules in the row were 12, 24, and 48 for 40, 80 and 160 kg K $ha^{-1}$ respectively. The pots were plastic (Nutron Tropical Planters) with two compartments. The top compartment was for soil and the bottom (0.5 L) for water, with two compartments linked by a wick. The treatments were arranged in a completely randomized design with three replications. Soil water content was maintained at 70% field capacity (F.C.) for the first experiment, and 50% F.C. for the second. After seeding, seed germination of the three crops was determined at day seven. The dry matter of seedlings at day 21 was determined by harvesting the shoots and drying at 65°C. The seeding was started on March 20 for the first experiment, and May 23 for the second. There was no supplemental light during the night in the greenhouse.

The field experiment was conducted at the Ellerslie Research Station of the University of Alberta on June 16, 1995. The soil was a Black Chernozem of clay loam texture with 36% F.C. Unfortunately, only barley (cv. Harrington) was used as the test crop. The K application rate was 0, 21, 42 and 84 kg K $ha^{-1}$ for non-coated KCl, and Coated II. The K fertilizers were applied in the seedrow. Prior to seeding, nitrogen (as urea) fertilizer was broadcasted at a rate of 135 kg N $ha^{-1}$. Phosphorus (as triple super phosphate) fertilizer was applied at 34 kg P $ha^{-1}$ with seeds. Seeds were applied at a rate of 80 kg $ha^{-1}$ with 22.9-cm spacing at a 2.5-cm depth. The experimental design was a randomized complete block and there were four replications. In each plot there were four rows 6.1 m long. At 34 days after seeding, the number of plants per meter row and dry matter per 2-meter row were determined. Harvested shoots were dried at 65°C and weighed.

The results from the greenhouse and field experiments were analyzed with ANOVA followed by the Least Significant Differences ($p \leq 0.05$). The results of Coated II from the field experiment were contrasted with the non-coated KCl treatments.

The results in the laboratory of coated KCl in water showed marked differences depending on the number of layers on the coat (Fig. 1). It was thought that the sharp corners on KCl crystals might render the coating of KCl ineffective. The Coated I had 56, 35 and 29% of the KCl remaining undissolved as non-coated KCl for 2, 7 and 19 days, respectively. The Coated II was even more effective, at 84, 73 and 60% remaining undissolved for 2, 7 and 19 days, respectively.

The results from the greenhouse experiments indicated a negative effect on the K fertilizer without coating (depending on rate of K) for seed germination and plant height, especially when comparing canola to wheat and barley (Table 1). Our results showed that coating increased the number of seeds germinated per pot and plant height in many cases. For example, there were no canola seeds germinated at 160 kg K $ha^{-1}$ of Non-coated KCl at 70% F.C., but there were 4 and 7 seeds germinated per pot with Coated I and Coated II, respectively. Paralleled with seed germination was the plant height. The plant height of canola was 3.9 cm for Coated II, 3.6 cm for Coated I and no growth for non-coated KCl at 160 kg K $ha^{-1}$. Among the three crops, canola appeared more sensitive to KCl relative to wheat and barley. At 80 kg K $ha^{-1}$, for example, there were 5 germinated seeds of canola from Non-coated KCl at 70% F.C., but there were 7 germinated for both wheat and barley. The dry matter at 21 days after seeding was higher with Coated KCl than with the Non-coated KCl treatments (Table 2; contrast of non-coated vs Coated I or II = 0.0057 and 0.0001, respectively). At 70%, for example, the dry matter of canola from Non-coated KCl at 160 kg K $ha^{-1}$ was 0.12 g, but it was 0.48 g for Coated I and 0.77 g for Coated II at the same rate. That is, the canola had more dry matter than Coated II compared to Coated I with 70% F.C. at 21 days (contrast of Coated II compared to Coated I = 0.0009) or Coated II compared to Coated I with 50% F.C. ($LSD_{0.05}$ = 0.26).

The results of the field experiment with barley showed that Coated II had a higher number of plants per meter row, and higher dry matter in the two-meter row (Table 3). The coated KCl treatments had 63, 71 and 71 (average of 68) plants per meter row at 21, 42 and 84 kg K $ha^{-1}$, respectively. However, the non-coated KCl treatment had fewer plants with 42, 51 and 36 (average of 43) plants per meter row at 21, 42 and 84 kg K $ha^{-1}$, respectively. The reduction in seed germination with non-coated KCl addition was not caused by lack of moisture in soil, but by the salt effect of the KCl fertilizer. In the first week after seeding, the experimental site received 7 mm of precipitation, and most of the rain fell in the second day after seeding. The number of plants per meter row was greater from Coated compared to Non-coated KCl (Coated $LSD_{0.05}$ = 8; Table 3). Considering the dry matter at the rate of 84 kg K $ha^{-1}$, the Coated II had 15.9 g from 1 m length of row but Coated I had only 7.6 g from the same length of row. (Interaction $LSD_{0.05}$ = 1.78 g; Table 3).

We did not have a cost for commercial coating of KCl fertilizer, but one might estimate that the 2.5% coating of our material in KCl fertilizer would be, say, twice the amount of the non-coated KCl fertilizer. Our coating material may be a real possibility for use in the field. Malhi et al. (1993) showed that K fertilizer had clearly more yield increase in mature barley and canola if the K fertilizer was placed with the seed-row, relative to incorporation or banding away from the seed-row. Further, our results indicate that coating, compared to non-coating, in the greenhouse and the field increases the yield of dry matter in seedrow-placed KCl fertilizer.

In conclusion, the coated KCl applied in the seedrow had a less adverse effect on seed germination and seedling growth as compared to the non-coated KCl. This was more pronounced with canola relative to barley or wheat. With an inexpensive coating for KCl, seed-placed coated KCl could become practical in western Canada, and elsewhere, which will benefit crop growth in the early stages, especially for small-seeded crops.

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Table I. Effect of sources and rates of KCl on number of seeds germinated and shoot height at seven days after seeding at 70% and 50% field capacity soil water content.

| Treatment | | Experiment 1, 70% F.C. | | | Experiment 2, 50% F.C. | | |
|---|---|---|---|---|---|---|---|
| Coating | Rate of K (kg K ha) | Canola | Wheat | Barley | Canola | Wheat | Barley |
| | | **Number of Seeds Germinated** | | | | | |
| Nil | 0 | 8 | 8 | 8 | 7 | 8 | 8 |
| Non-coated | 40 | 7 | 8 | 8 | 8 | 8 | 8 |
| Non-coated | 80 | 5 | 7 | 7 | 5 | 7 | 8 |
| Non-coated | 160 | 0 | 5 | 4 | 0 | 0 | 3 |
| Coated I | 40 | 7 | 8 | 8 | 8 | 8 | 8 |
| Coated I | 80 | 7 | 8 | 8 | 5 | 8 | 8 |
| Coated I | 160 | 4 | 7 | 7 | 5 | 7 | 8 |
| Coated II | 40 | 8 | 8 | 8 | 6 | 8 | 8 |
| Coated II | 80 | 8 | 8 | 8 | 6 | 7 | 8 |
| Coated II | 160 | 7 | 6 | 7 | 6 | 8 | 8 |
| Prob > F | | 0.0001 | 0.0020 | 0.0342 | 0.0001 | 0.0001 | 0.0001 |
| $LSD_{0.05}$ | | 1.7 | 1.2 | 2.2 | 1.7 | 0.8 | 1.5 |
| Contrast | | | | | | | |
| Non vs Coated I | | 0.0002 | 0.0671 | 0.0800 | 0.0093 | 0.0001 | 0.0003 |
| Non vs Coated II | | 0.0001 | 0.1223 | 0.1125 | 0.0018 | 0.0001 | 0.0003 |
| Coated I vs II | | 0.0040 | 0.7502 | 0.8555 | 0.4803 | 0.6309 | 1.0000 |
| | | **Plant Height (cm)** | | | | | |
| Nil | 0 | 5.0 | 11.7 | 11.3 | 6.2 | 11.2 | 12.6 |
| Non-coated | 40 | 2.0 | 10.4 | 8.4 | 2.6 | 8.8 | 10.2 |
| Non-coated | 80 | 1.5 | 3.9 | 5.4 | 1.9 | 3.0 | 5.9 |
| Non-coated | 160 | 0.0 | 2.5 | 2.9 | 0.0 | 0.3 | 2.2 |
| Coated I | 40 | 4.3 | 12.0 | 11.5 | 5.0 | 11.4 | 11.9 |
| Coated I | 80 | 3.0 | 9.7 | 9.4 | 5.7 | 11.2 | 12.4 |
| Coated I | 160 | 3.6 | 7.8 | 8.2 | 4.7 | 8.1 | 9.5 |
| Coated II | 40 | 4.5 | 11.4 | 9.8 | 7.1 | 11.0 | 12.7 |
| Coated II | 80 | 5.0 | 10.5 | 9.5 | 6.0 | 11.2 | 11.6 |
| Coated II | 160 | 3.9 | 9.2 | 8.0 | 5.7 | 11.6 | 11.9 |
| Prob > F | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| $LSD_{0.05}$ | | 1.30 | 1.53 | 1.66 | 1.18 | 1.53 | 1.81 |
| Contrast | | | | | | | |
| Non vs Coated I | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Non vs Coated II | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Coated I vs II | | 0.0315 | 0.0839 | 0.4902 | 0.0013 | 0.0226 | 0.1251 |

Table 2. Effect of sources and rates of KCl on shoot dry mass at 21 days after seeding at 70 and 50% field capacity soil water content.

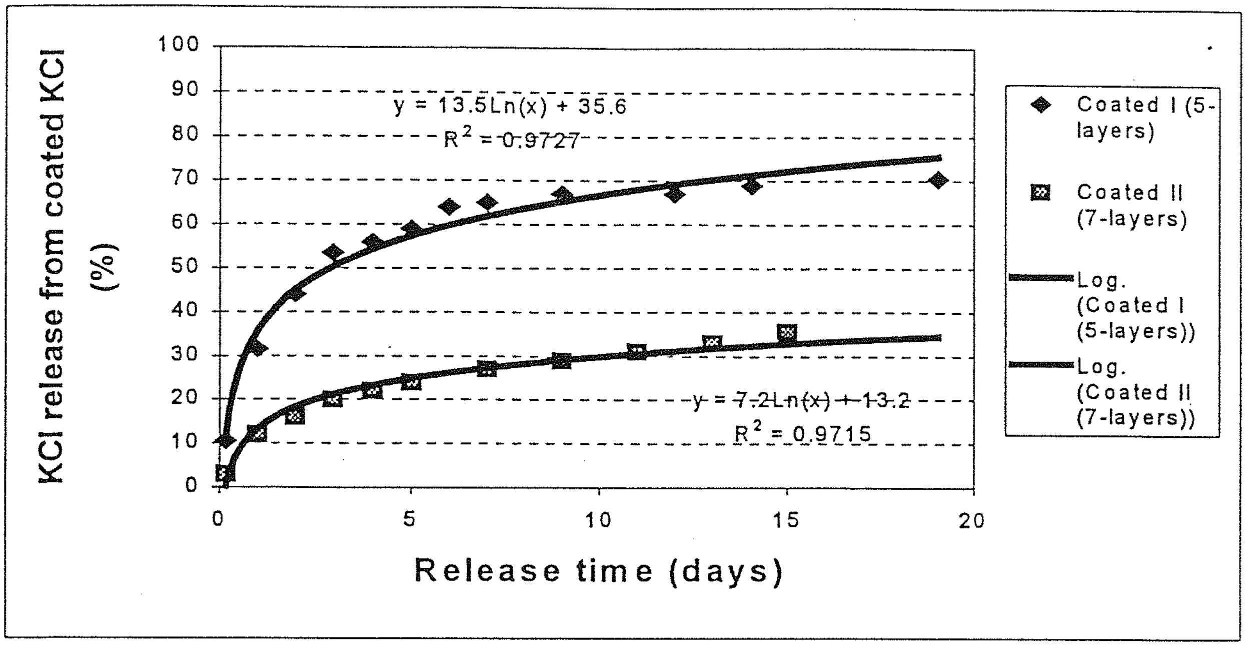
| Treatment | | Dry Matter per pot (g) | | | | | |
|---|---|---|---|---|---|---|---|
| | Rate of K | Experiment 1, 70% F.C. | | | Experiment 2, 50% F.C. | | |
| Coating | (kg K $ha^{1}$) | Canola | Wheat | Barley | Canola | Wheat | Barley |
| Nil | 0 | 0.69 | 0.74 | 0.99 | 1.07 | 1.35 | 1.78 |
| Non-coated | 40 | 0.61 | 0.92 | 1.01 | 1.08 | 1.32 | 1.78 |
| Non-coated | 80 | 0.47 | 0.65 | 0.94 | 1.00 | 0.90 | 1.38 |
| Non-coated | 160 | 0.12 | 0.54 | 0.69 | 0.31 | 0.68 | 0.93 |
| Coated I | 40 | 0.64 | 0.92 | 1.07 | 1.08 | 1.32 | 1.73 |
| Coated I | 80 | 0.58 | 0.88 | 0.98 | 1.05 | 1.39 | 1.78 |
| Coated I | 160 | 0.48 | 0.84 | 1.04 | 0.74 | 1.14 | 1.64 |
| Coated II | 40 | 0.72 | 1.17 | 0.92 | 1.02 | 1.43 | 1.78 |
| Coated II | 80 | 0.84 | 0.86 | 1.19 | 1.06 | 1.51 | 1.74 |
| Coated II | 160 | 0.77 | 0.79 | 1.18 | 1.18 | 1.45 | 1.80 |
| Prob > F | | 0.0001 | 0.0085 | 0.0011 | 0.0001 | 0.0005 | 0.0001 |
| $LSD_{0.05}$ | | 0.20 | 0.27 | 0.18 | 0.26 | 0.33 | 0.21 |
| Contrast | | | | | | | |
| Non vs Coated I | | 0.0057 | 0.0270 | 0.0080 | 0.0348 | 0.0023 | 0.0001 |
| Non vs Coated II | | 0.0001 | 0.0043 | 0.0003 | 0.0005 | 0.0001 | 0.0001 |
| Coated I vs II | | 0.0009 | 0.4158 | 0.1842 | 0.0803 | 0.0581 | 0.3270 |

Table 3. Number of plants and seedling dry matter of barley as affected by seed-placed KCl and coated KCl in the field at 34 days.

| Rate of K ($kg\ K\ ha^{-1}$) | Number of plants per meter row[z] | | | Dry matter (g) per 1 metre row[z] | | |
|---|---|---|---|---|---|---|
| | No coat[z] | Coated II | Mean | No coat[z] | Coated II | Mean |
| 0 | 67 | 69 | 68 | 11.31 | 12.38 | 11.84 |
| 21 | 42 | 63 | 53 | 11.14 | 12.65 | 11.89 |
| 42 | 51 | 71 | 61 | 9.89 | 13.35 | 11.62 |
| 84 | 36 | 71 | 54 | 7.60 | 15.89 | 11.74 |
| Mean | 49 | 63 | | 9.98 | 13.57 | |
| Coating $LSD_{0.05}$ | | 8 | | | 1.78 | |
| Rate $LSD_{0.05}$ | | 11 | | | 2.52 | |
| Interaction $LSD_{0.05}$ | | 15 | | | 3.57 | |

[z] The row was 23 cm apart.

Fig. 1. Release of $KCl$ from coated $KCl$ fertilizer into water at 23°C.


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))

17 April

# COATED KCl INCREASES BARLEY K UPTAKE IN TWO ALBERTA SOILS IN A GREENHOUSE EXPERIMENT

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# ABSTRACT

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.* cv 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 days after sowing. While dry matter was unaffected, coated KCl generally reduced plant K concentration and K uptake at 40 days and increased plant K concentration and K uptake at 76 days. We concluded the KCl coated with polyurethane can be more available to crops in K deficient soils.

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

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% (w/w) 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 5 coats (2.5% polyurethane) and KCl II with 7 coats (3.5% polyurethane), were prepared. The release rates to distilled water (Figure 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 the soil. Another nitrogen application (132 mg N/pot) was made 14 days 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 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 one week 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 June 02 to August 17, 1995. No supplemental light was used and the greenhouse temperature was 23° ± 5° C. Above ground biomass was harvested at 40 or 76 days 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 days barley dry matter was not significantly different among treatments on either soil ($p > .05$, 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 <.05) and, except for the high K application on soil 2 (LSD ≠ .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 < .05). On soil 2 there was no difference between coatings in K uptake at the low application (LSD ≠ .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 < .05), and lower K uptakes, particularly on soil 1 (contrasts < .05).

At 76 days, as at 40 days, there were no significant differences in dry matter production on either soil ($p > .05$, Table 1). For soil 1, compared to 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 < .05). Further, both K concentration and K uptake were significantly greater for KCl I than for KCl II (contrast <.05).

These concentrations and uptake data at 40 days 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 days 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 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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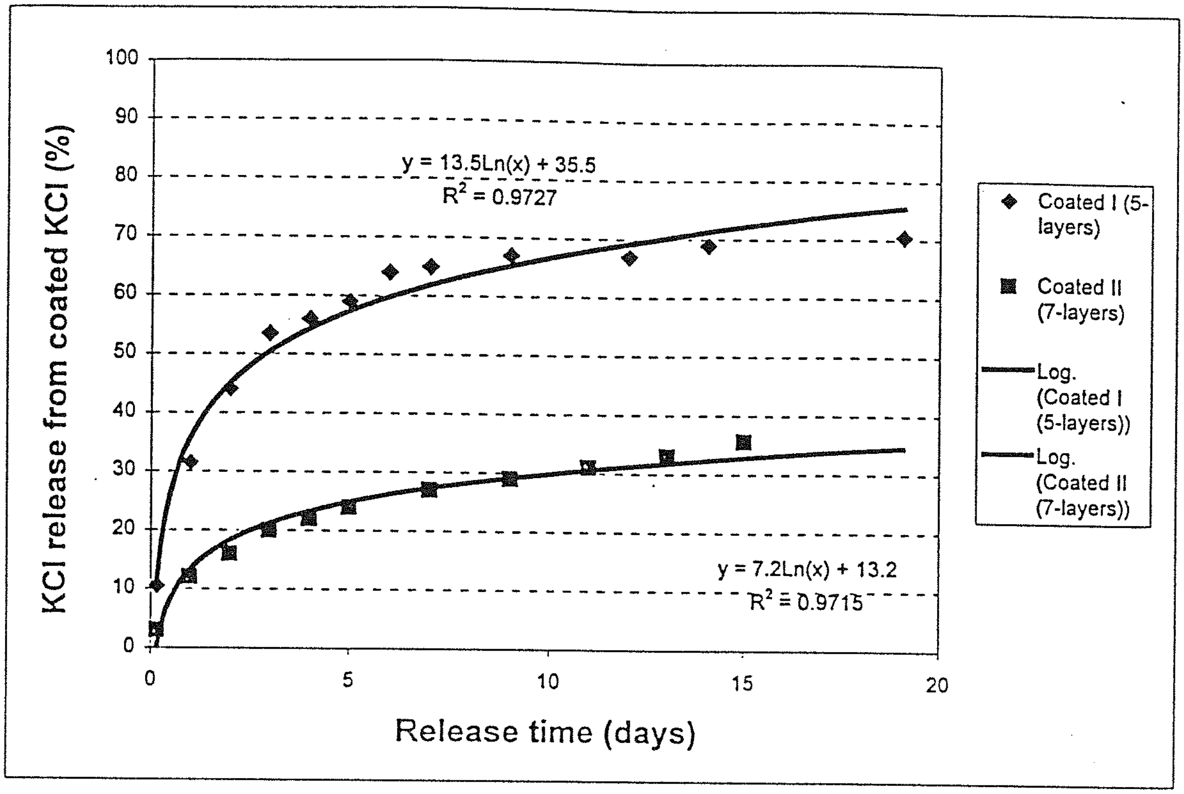
**Table 1. Barley dry matter, K concentration, and K uptake from coated and non-coated KCl fertilizer at 40 and 76 days after sowing.**

| Treatment | | SOIL 1 | | | SOIL 2 | | |
|---|---|---|---|---|---|---|---|
| | | Dry matter | Plant K | K uptake | Dry matter | Plant K | K uptake |
| Coating | mg K/pot | g/pot | mg/g | mg/pot | g/pot | mg/g | mg/pot |
| **IMMATURE (40 Days)** | | | | | | | |
| 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 Days)** | | | | | | | |
| 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.

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


KCl release from coated KCl (%)
100
90
80
70
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50
40
30
20
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0
y = 13.5Ln(x) + 35.5
R2 = 0.9727
y = 7.2Ln(x) + 13.2
R2 = 0.9715
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15
20
Release time (days)
Coated I (5-layers)
Coated II (7-layers)
Log. (Coated I (5-layers))
Log. (Coated II (7-layers))