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 restricts seed germination and seedling growth. At the same time, our new coating of KCl fertilizer needed testing in soil. Two greenhouse experiments with canola, barley and wheat, and one experiment in the field with barley were conducted to determine if seed-placed coated KCl fertilizer reduced seed germination and seedling growth. The results showed that the number of germinated seeds and seedling dry matter were higher with the seed-placed coated KCl than the seed-placed non-coated KCl.

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

In Western Canada, approximately 1.8×10^6 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, a low rate) for barley and rapeseed in different areas of Central Alberta. The results showed much large 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 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 for cereal crops and 17 kg K/ha 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 polyolifin 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 slowed 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 of several crops.

We have conducted four experiments, one in the laboratory with coating of KCl, two in the greenhouse, one field investigation at the Ellerslie Research Station. In the four experiments, there were three sources of KCl fertilizers, non-coated KCl, 5-layers coated KCl (Coated I) and 7-layers coated KCl (Coated II).

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 the laboratory of the University of Alberta. Each layer was approximately 0.3% of the KCl granulate mass. The coated KCl used was the Coated I (5-layers) and Coated II (7-layers) and the rate released was determined daily for 19 days in water at 23°C. There were three water solutions each consisted of 20 granules of non-coated KCl, Coated I (5-layers) and Coated II (7-layers), 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, organic matter, 8.5%, and field capacity (F.C.), 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. 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) in a depth of 1 cm. KCl fertilizer granules were placed side by side with the seeds. There were three sources of KCl fertilizers: non-coated KCl, Coated I (5-layers), Coated II (7-layers). The number of granules in the row was 12, 24, and 48 for 40, 80 and 160 kg K/ha, respectively. The pots were plastic (Nutron Tropical Planters) with two compartments. The top compartment was for soil and bottom (0.5 L) for water, and the two compartments was linked by a wick. The experiments were complete-randomized design with three replicates. 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 the seventh day. The dry matter of seedlings at the 21st day 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% water at 100% field capacity. Only barley (cv. Harrington) was used as the test crop. The K application rate was 0, 21, 42 and 84 kg K/ha for non-coated KCl, and Coated II (7-layers). The K fertilizers were applied in seedrow. Prior to seeding, nitrogen (as urea) fertilizer was broadcasted at a rate of 135 kg N/ha. Phosphorus (as triple super phosphate) fertilizer was applied at 34 kg P/ha with seeds. Seeds were applied at a rate of 80 kg/ha with 22.9-cm spacing at 2.5-cm depth. The experiment was a complete-randomized block design. There were four replicates and on each treatment of replicate there were four rows with 6.1 m long. At 34 days after seeding, number of plants per meter row and dry matter per 2-meter row was 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. 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 coating depending on the number of layers on the coat (Fig. 1). We thought that the sharp corners on KCl crystals would be an ineffective coating for the KCl fertilizer. The Coated I (5-layers) had 56, 35 and 29% in the original form for 2, 7 and 19 days, respectively. The Coated II (7-layers) was even more effective, at 84, 73 and 60% for 2, 7 and 19 days, respectively.

The results from the greenhouse experiments showed that rate of K application decreased the amount of seed germination and shoot height in most cases (Table 1). For example, at 40 kg K/ha in canola, the average number of germinated seeds from three

fertilizers at 50% F.C. was 7, and the shoot height was 4.9 cm, whereas, when the rate was increased to 160 kg K/ha, the average number of germinated seeds was 2 (with no germination in non-coated KCl treatments), and plant height was 3.5 cm (Table 1). The coated KCl had less impact in decreasing seed germination and shoot height compared to non-coated KCl, especially Coated II (7-layers). For example, the average plant height of canola from non-coated KCl with the rates of 40, 80 and 160 kg K/ha at 50% F.C. was 1.5 cm, but it was 5.0 and 6.3 cm for the Coated I (5-layers) and Coated II (7-layers), respectively. Comparing the three crops, canola appeared more sensitive to KCl in comparison to barley and wheat. At 160 kg K/ha, there was no germination for canola in the non-coated KCl treatment, but there were germinated seeds for barley and wheat for both 50 and 70% F.C.. The dry matter at the 21st day after seeding were higher with the coated KCl than with the non-coated KCl treatments in most cases (Table 2). The dry matter from Coated II (7-layers) treatments in most cases was higher than from the Coated I (5-layers) treatments. Coated I (5-layers) still restricted seedling growth even though that restriction was not as great as the non-coated KCl.

The results from the field experiment showed that Coated II (7-layers) resulted in a higher number of plants per meter row, and higher dry matter in two meter row (Table 3). The coated KCl treatments had 68 plants per meter row as compared to 43 plants from the non-coated KCl treatment. 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 seven mm rain precipitation, and most of the rain fell in the second day after seeding. The dry matter, on

the other hand, declined from 22.3 g of 21 kg K/ha to 15.2 g of 84 kg K/ha for non-coated KCl, but increased from 25.3 g at 21 kg K/ha to 31.8 g at 84 kg K/ha for the coated KCl.

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

We acknowledge that the research was funded by the Alberta Agricultural Research Institute and Potash & Phosphate Institute of Canada, and technical assistance for the field research was provided by Zhixiong Zhang of the Department of Renewable Resources, University of Alberta, and by the Agronomy Unit, Alberta Agriculture, Food, and Rural Development.

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Table 1. Effect of sources and rates of KCl on shoot height and number of seeds germinated in seven days after seeding at 70 and 50% field capacity soil water content.

Crop	Source of KCl	Experiment 1, 70% F.C. Rate of application (kg K/ha)					Experiment 2, 50% F.C. Rate of K application (kg K/ha)				
		Nil	40	80	160	LSD 0.05	Nil	40	80	160	LSD 0.05
		..... cm					..... cm				
Canola											
	Non coated	5.0 (8)†	2.0 (7)	1.5 (5)	0.0 (0)	0.1	6.2 (7)	2.6 (8)	1.9 (5)	0.0 (0)	0.1
	Coated I	5.0 (8)	4.3 (7)	3.0 (7)	3.6 (4)	0.6	6.2 (7)	5.0 (8)	5.6 (5)	4.5 (5)	0.4
	Coated II	5.0 (8)	4.5 (8)	5.0 (8)	3.9 (7)	0.1	6.2 (7)	7.1 (6)	6.0 (6)	5.7 (3)	0.2
	LSD 0.05		0.2	0.1	0.3			0.2	0.1	0.1	
Barley											
	Non coated	11.3 (8)	8.1 (8)	5.5 (7)	2.9 (4)	0.3	12.6 (8)	10.2 (8)	5.9 (8)	2.2 (3)	0.9
	Coated I	11.3 (8)	11.4 (8)	9.4 (8)	7.7 (7)	0.4	12.6 (8)	11.9 (8)	12.5 (8)	9.5 (8)	0.4
	Coated II	11.3 (8)	9.7 (8)	9.4 (8)	8.4 (7)	0.2	12.6 (8)	12.7 (8)	11.6 (8)	11.9 (8)	0.1
	LSD 0.05		0.2	0.3	0.3			0.3	0.3	0.5	
Wheat											
	Non coated	11.4 (8)	10.0 (8)	3.9 (7)	2.5 (5)	0.3	11.1 (8)	8.8 (8)	3.0 (7)	0.3 (1)	0.3
	Coated I	11.4 (8)	12.0 (8)	9.7 (8)	7.8 (7)	0.1	11.1 (8)	11.4 (8)	11.1 (8)	8.2 (6)	0.4
	Coated II	11.4 (8)	11.4 (8)	11.0 (8)	9.6 (6)	0.4	11.1 (8)	9.8 (8)	11.3 (7)	12.1 (8)	0.3
	LSD 0.05		0.1	0.4	0.3			0.3	0.4	0.1	

† Numbers in the parenthesis were number of seeds germinated in the 7th day after seeding.

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.

Crop	Source of KCl	Experiment 1, 70% F.C. Rate of application (kg K/ha)					Experiment 2, 50% F.C. Rate of K application (kg K/ha)				
		Nil	40	80	160	LSD 0.05	Nil	40	80	160	LSD 0.05
		..... g					..... g				
Canola											
	Non coated	0.69	0.61	0.47	0.12	0.007	1.07	1.07	1.00	0.31	0.007
	Coated I	0.69	0.64	0.58	0.48	0.004	1.07	1.08	1.05	0.74	0.01
	Coated II	0.69	0.72	0.84	0.77	0.002	1.07	1.02	1.06	1.18	0.004
	LSD 0.05		0.002	0.006	0.009			0.006	0.02	0.004	
Barley											
	Non coated	0.99	1.01	0.94	0.69	0.002	1.78	1.78	1.38	0.93	0.009
	Coated I	0.99	1.07	0.98	1.04	0.002	1.78	1.73	1.78	1.64	0.008
	Coated II	0.99	0.92	1.19	1.18	0.006	1.78	1.78	1.74	1.80	0.004
	LSD 0.05		0.005	0.007	0.002			0.007	0.006	0.005	
Wheat											
	Non coated	0.74	0.92	0.65	0.54	0.02	1.35	1.32	0.90	0.68	0.002
	Coated I	0.74	0.92	0.88	0.84	0.004	1.35	1.32	1.39	1.14	0.01
	Coated II	0.74	1.17	0.86	0.79	0.01	1.35	1.43	1.25	1.45	0.008
	LSD 0.05		0.007	0.004	0.006			0.002	0.006	0.009	

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	Number of barley plants per meter row			Oven dry mass of barley seedlings (g/2 m)		
(kg K/ha)	Non-coated KCl	Coated KCl	Probability	Non-coated KCl	Coated KCl	Probability
0	66	69	NS	22.6	24.8	NS
21	42	63	0.0028	22.3	25.3	NS
42	51	71	0.0039	19.8	26.7	0.0803
84	36	71	0.0001	15.2	31.8	0.0006
LSD 0.05	12	15		6.2	6.2	

NS-not significant at 10%.

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

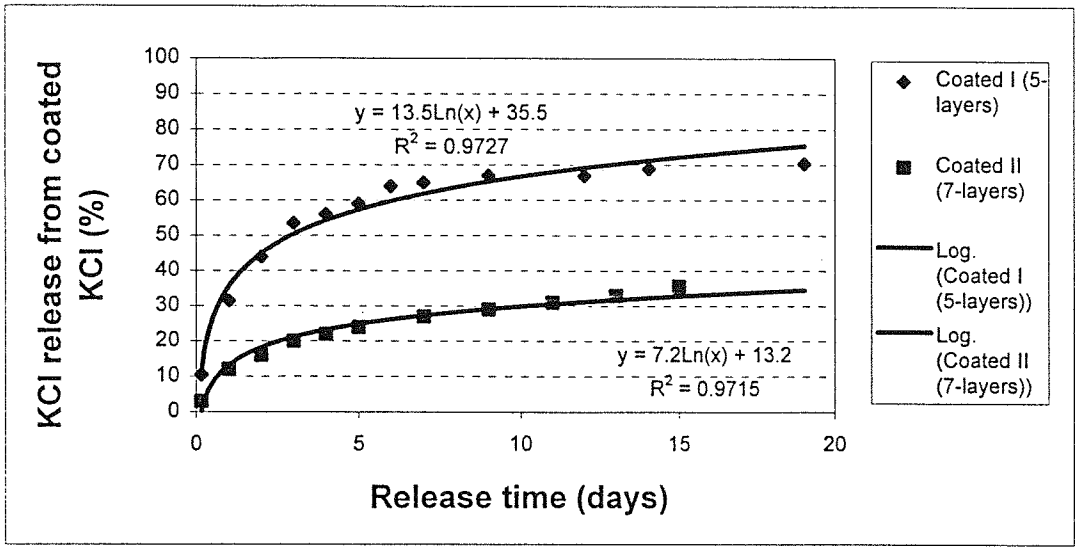
KCl release from coated KCl (%)
100
90
80
70
60
50
40
30
20
10
0
y = 13.5Ln(x) + 35.5
R2 = 0.9727
y = 7.2Ln(x) + 13.2
R2 = 0.9715
0
5
10
15
20
Release time (days)
Coated I (5-layers)
Coated II (7-layers)
Log. (Coated I (5-layers))
Log. (Coated II (7-layers))

Fig 1