SHORT COMMUNICATION

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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Zhang, M., Nyborg, M. and Solberg, E. D. 1998. **Seed germination and seedling dry matter production of canola, barley and wheat as affected by seed-placed KCl and polymer-coated KCl.** Can. J. Soil Sci. **78**: 611–614. 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

Zhang, M., Nyborg, M. et Solberg, E. D. 1998. **Effets de l'épandage en localisation dans la ligne de semis du KCL, ordinaire ou enrobé dans un polymère sur la germination et sur la croissance plantulaire du colza canola, de l'orge et du blé.** Can. J. Soil Sci. **78**: 611–614. Le KCL placé dans la ligne de semis a souvent des effets adverses sur la germination et sur la croissance de la plantule à cause de son indice de salinité élevé. Ces effets négatifs peuvent être amoindris par l'enrobage des granules de KCL dans un polymère. C'est ce que nous avons voulu vérifier dans deux expériences en serre sur colza canola, orge et blé et dans une expérience au champ sur orge. Les résultats obtenus montrent que le nombre de grains germés et la production de matière sèche par la plantule étaient plus élevés en présence du KCL enrobé que du KCL ordinaire.

Mots clés: KCL engrais, KCL à enrobage de polymère, germination, production de matière sèche, plantule

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^{-1}, a low rate) for barley and rapeseed 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. Polyolefin coated KCl fertilizers have been 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 polyurethane-coated KCl fertilizer; and to find if the coated KCl, compared with 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 (five layers of polymer) and coated II (seven 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 diam. 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 d 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, OH).

In the two greenhouse experiments in 1997, a Black Chernozem soil with a pH of 7.5, 8.5% organic matter, **field capacity (FC)** of 32.6%, and three crops, canola (*Brassica napus* 'Legacy'), barley (*Hordeum vulgare* L. 'Harrington')

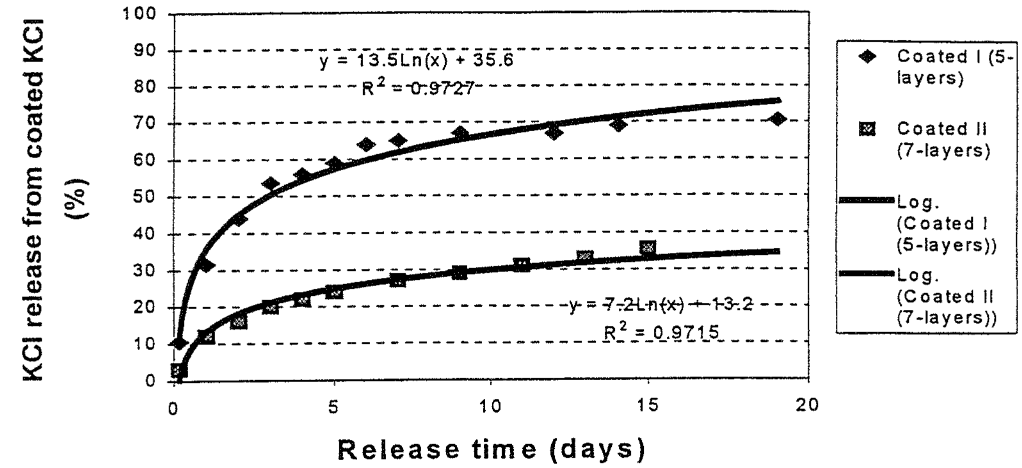

Fig. 1. Release of KCl from coated KCl fertilizer into water at 23°C.

Table 1. 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	Rate of K	Experiment 1 (70% FC)			Experiment 2 (50% FC)		
Coating	(kg K ha^{-1})	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

and wheat (*Triticum aestivum* L. '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

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)					
		Experiment 1 (70% FC)			Experiment 2 (50% FC)		
Coating	Rate of K ($kg\ K\ ha^{-1}$)	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 d

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 rows were 23 cm apart.

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% FC for the first experiment, and 50% FC for the second. After seeding, seed germination of the three crops was determined at day 7. 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 23 May 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 16 June 1995. The soil was a Black Chernozem of clay loam texture with 36% FC. 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 seed row. 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 d after seeding, the number of plants per meter row and dry matter per 2-m 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 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 d, respectively. The coated II was even more effective, at 84, 73 and 60% remaining undissolved for 2, 7 and 19 d, 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 with 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% FC, 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 five germinated seeds of canola from non-coated KCl at 70% FC, but there were seven germinated for both wheat and barley. The dry matter at 21 d 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 with coated II compared with coated I with 70% FC at 21 d (contrast of coated II vs. coated I = 0.0009).

The results of the field experiment with barley showed that coated II had more 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 with non-coated KCl (coating $LSD_{0.05}$ = 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 non-coated KCl had only 7.6 g from the same length of row (interaction $LSD_{0.05}$ = 3.57 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 with non-coating, in the greenhouse and the field increases the yield of dry matter in seed row-placed KCl fertilizer.

In conclusion, the coated KCl applied in the seed row had a less adverse effect on seed germination and seedling growth than the non-coated KCl. This was more pronounced with canola than with 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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