Application of Seed-row Potash to Soils with High Available Potassium Levels

Rigas E. Karamanos, Norm A. Flore and John T. Harapiak

Western Co-operative Fertilizers Limited, P.O. Box 2500, Calgary, Alberta, Canada T2P 2N1

Abstract

A large number of experiments were conducted from 1989 to 1998 on western Canadian prairie soils with barley (124), hard red spring wheat (52), canola (6) and peas (13) to ascertain the response of these crops to seed-row applied KCl fertilizer. All soils contained potassium levels in excess of what is considered a critical level for obtaining a yield response to potassium due to potassium deficiency. Statistically significant yield increases were obtained with thirty percent of the barley trials and twenty percent of wheat trials. Significant yield losses were observed with less than ten percent of the barley trails and less than twenty five percent of the wheat trials and in one canola trial. None of the assessed plant characteristics (days to maturity, plumpness, protein and root rot infection) revealed any significant benefit from application of Cl as either KCl or $CaCl_2$. There appeared to be a strong link between the probability of obtaining a significant response to seed-row applied KCl and barley variety. However, no clearly defined mechanism for the positive or negative responses could be drawn based on the determined parameters.

Introduction

Application of small amounts (10 to 20 lb K_2O/ac) of potassium chloride (common fertilizer forms 0-0-60 or 0-0-62) in the seed-row is becoming an increasingly common practice on the western Canadian prairies. This practice has been adopted in response to reports of benefits from the chloride portion of the fertilizer (Bonczkowski et al., 1988; Christensen et al., 1981; Engel and Grey, 1991; Fixen et al., 1986a,b; Goos et al., 1987; Goos et al., 1989). Yield responses to Cl have been attributed to disease suppression, although a number of the above researchers observed a yield increase without any connection to disease suppression. Other anecdotal benefits of placement of small amounts of KCl with the seed, e.g., responses to potassium itself due to proximity of root seedlings to readily available potassium in cool springs, aversion of mild lodging and promotion of early maturity are also often quoted as anticipated benefits.

Western Co-operative Fertilizers Limited has had an active research program to assess responses to seed-placed potassium in soils containing “available” potassium levels above what is considered as a critical concentration due to deficiency. The objective of this study was to compile all experimental data from 1989 to 1998 in order to establish the probability of obtaining either a yield response or improvement in crop characteristics of common crops due to low rates of seed-row applied potassium.

Materials and Methods

All field experiments were conducted in the western Canadian prairie Provinces with wheat, barley, canola and peas. An attempt was made to maintain uniformity in experimental design over the years. The experimental designs and number of experiments for each crop are included in Tables 1 through 4.

Table 1. Basic experimental designs followed for the study of seed-row applied potassium.

Design	Brief Description	Barley No. of experi-ments	Wheat No. of experi-ments	Canola No. of experi-ments	Peas No. of experi-ments
1	Treatments: Control and KCl Fertilizer rates: N banded at three rates 0, 54 and 81 lb/acre, P_2O_5 applied both as seed-row at a rate of 13 lb/acre and band at a rate of 27 lb/acre and K_2O seed-row applied at two rates of 0 and 27 lb/acre Observations: Yield, Protein, Plumpness and Days to Maturity	90	--	--	--
2	Treatments: Control and KCl Fertilizer rates: N banded, P_2O_5 seed-row applied at one rate of 27 lb/acre and K_2O seed-row applied at two rates of 0 and 27 lb/acre Observations: Yield and Days to Maturity	11	31		13
3	Treatments: Control and KCl Fertilizer rates: N seed-placed as urea at four rates of 0, 13, 27 and 40 lb/acre, P_2O_5 seed-row applied at one rate of 27 lb/acre and K_2O seed-row applied at three rates of 0, 13 and 27 lb/acre. Observations: Yield and Days to Maturity	3	2		
4	Treatments: Control, KCl, K_2SO_4 and $CaCl_2$ Fertilizer rates: N banded, P_2O_5 seed-row applied at one rate of 27 lb/acre and K_2O seed-row applied at two rates of 0 and 27 lb/acre Parameters measured: Yield and Percentage Root Rot	10	17	1	
5	Treatments: Control and KCl Fertilizer rates: N banded, P_2O_5 seed-row applied at one rate of 27 lb/acre and K_2O seed-row applied at three rates of 0, 13 and 27 plus 40 (wheat and canola) lb/acre. Observations: Yield, Protein, Plumpness and Days to Maturity	9	2	5	
	TOTAL	124	52	6	13

Fertilizer treatments were arranged in a randomized complete block design with six replicates. Individual plots were 6-ft x 40-ft and contained eight rows 9 in. wide. All experiments, other than the ones where urea was placed with the seed (Table 1 and 2), received a blanket application of banded nitrogen as urea at the soil testing recommended rate.

In seventeen of the experiments carried out with hard red spring wheat and thirteen carried out with barley, the impact of Cl was assessed by seed-row applying 20 lb Cl (27 lb K_2O) per acre, either as KCl or $CaCl_2$ and 27 lb K_2O as K_2SO_4 (Tables 1 and 2).

At maturity, six rows were harvested with a Wintersteiger combine and a sub-sample was obtained and the seed moisture determined. Seed yields were corrected to 13.5 % moisture for hard red spring wheat and barley, 10 % moisture for canola and 16 % moisture for peas.

Soil samples were taken prior to seeding from 0-6 in., 6-12 in. and 12-24 in. depths and submitted for routine fertility analysis. Potassium was extracted by a modification of the Kelowna extract (Qian et al., 1994).

The data were subjected to analysis of variance (ANOVA) and ranked probability (deJong et al., 1987), where appropriate. Least significant difference (LSD at P=0.05) was used to separate treatment means.

Results and Discussion

Barley

There were no statistical differences between the yields obtained by seed-row placement of 13 and 27 lb K_2O/acre applied as KCl in any of the twelve experiments (Designs 3 and 5, Table 1). Average yield for the control was 97.5 bu/acre and for the 13 and 27 lb K_2O/acre rates of application 98.4 and 98 bu/acre, respectively.

The ranked probability graph for barley is shown in Figure 1. According to this approach yield increases, which are defined as fertilized yield less check yield, were ranked from highest to lowest. Apparent yield increases and decreases were included in this ranking and significant yield increases were noted. Then the probability for each yield increase was plotted. This approach was also useful in determining the likelihood of obtaining economic returns from seed-row potassium application at 30 lb/acre. Although the probability of obtaining a yield increase to seed-row placed potassium was just under 60% and the breakeven point was at just over 40%, statistically significant yield increases started appearing at 30% probability (Figure 1).

An attempt was made to identify the cause of this apparent benefit by examining the ranked probability based on year of experiment (thus weather conditions), soil type, previous crop (barley, wheat, canola or peas) and barley variety. There were no apparent differences based on the crop year, soil type or previous crop (data not shown). The latter was especially surprising, as disease pressure tends to increase in a continuous cereal rotation. However, there were some distinct differences in yield responses of different varieties. Harrington (Figure 2) and B1602 (data not shown) showed proportionally greater probability (>40 %) for providing an economic yield increase, whereas B1215 in all but one case showed a yield decrease (Figure 3). A number of other varieties, such as Brier, Lacombe, Leduc, Manley and Stander produced inconclusive results.

In only less than 3% of the experiments was there a gain of one day in the Days to Maturity and in only less than 5% of the experiments was there a significant decrease in grain protein by one percentage. There were no significant increases in grain protein. Similarly, there was no apparent benefit in improvement of kernel plumpness, which is usually defined as desirable at levels greater than 85 % (Figure 4).

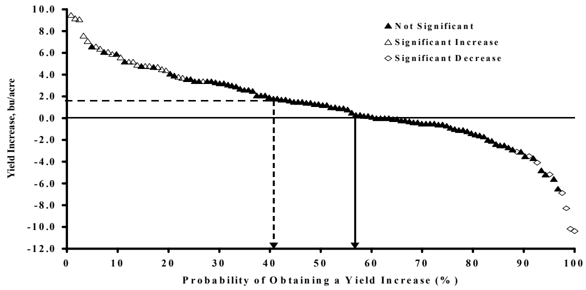

Figure 1. Probability of obtaining a yield increase of barley to seed-row applied 27 lb K_2O/acre. Dotted line represents break even point at CAN$180 per tonne of 0-0-60 and $125 per tonne of barley.

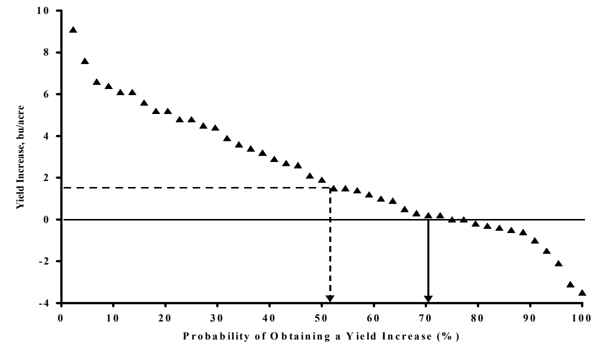

Figure 2. Probability of obtaining a yield increase of Harrington barley to seed-row applied 27 lb K_2O/acre. Dotted line represents break even point at CAN$180 per tonne of 0-0-60 and $125 per tonne of barley.

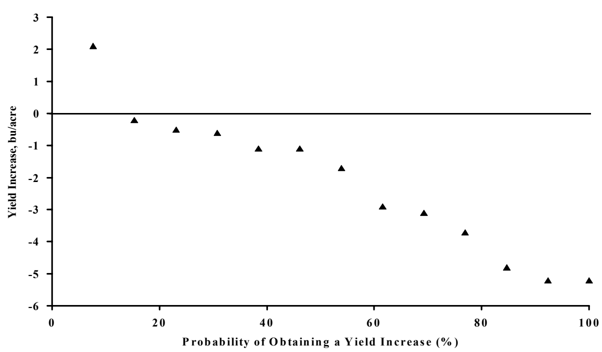

Figure 3. Probability of obtaining a yield increase of B1215 barley to seed-row applied 27 lb K_2O/acre. Dotted line represents break even point at CAN$180 per tonne of 0-0-60 and $125 per tonne of barley.

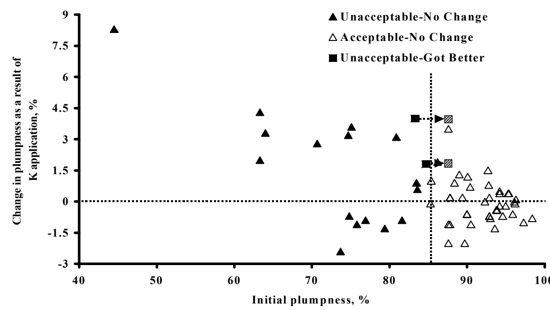

Figure 4. Effect of seed-row applied potassium on the kernel plumpness of malting type barley. Dotted line at 85 % plumpness represents desirable limit; ▶ ▨ represent a change in plumpness that resulted in improvement.

In only less than 3% of the experiments was there a gain of one day in the Days to Maturity and in only less than 5% of the experiments was there a significant decrease in grain protein by one percentage. There were no significant increases in grain protein. Similarly, there was no apparent benefit in improvement of kernel plumpness, which is usually defined as desirable at levels greater than 85 % (Figure 4).

Wheat

The ranked probability graph for wheat is shown in Figure 5. The probability of obtaining a yield increase to seed-row placed potassium was 50% and the breakeven point was at just over 30%, statistically significant yield increases started appearing at 20% probability.

There were no apparent differences based on the crop year, soil type or previous crop or variety of wheat (data not shown).

Yield responses to the two different carriers of Cl and K were significant in three out of the seventeen experiments with hard red spring wheat (Figure 6) and in none of the barley experiments (Figure 7). The responses were unrelated to Cl levels in the soil. There were no significant differences in the root rot infection of the various treatments.

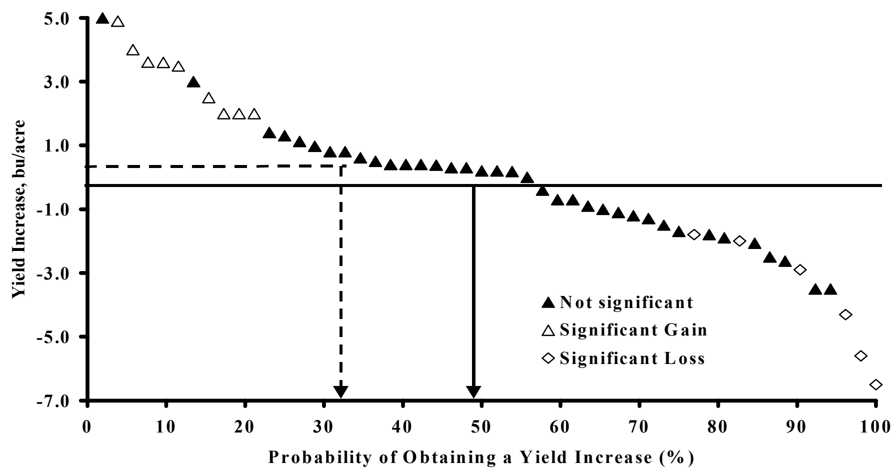

Figure 5. Probability of obtaining a yield increase of hard red spring wheat to seed-row applied 27 lb K_2O/acre. Dotted line represents break even point at CAN$180 per tonne of 0-0-60 and $210 per tonne of wheat.

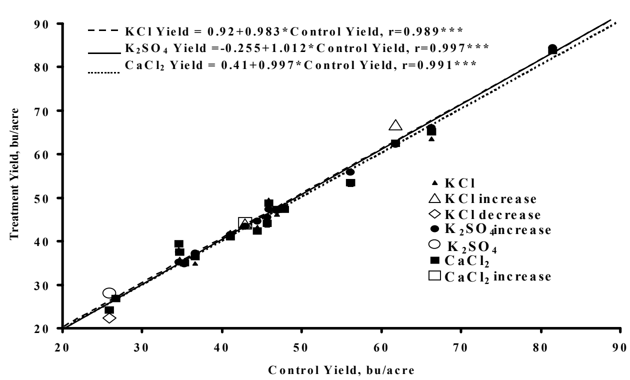

Figure 7. Relationship between the yield of hard red spring wheat that received 27 lb of K (20 lb Cl) as either KCl or K_2SO_4 or 20 lb Cl as $CaCl_2$ per acre and the control yield.

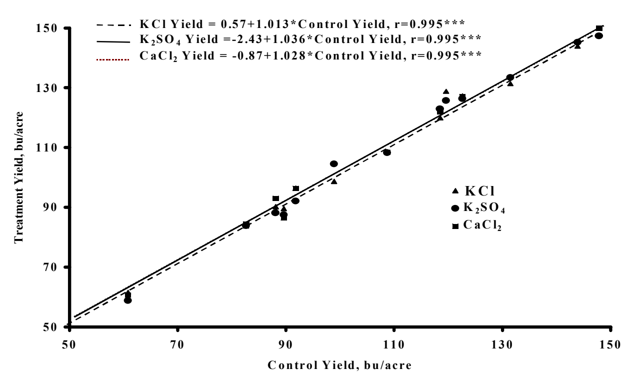

Figure 8. Relationship between the yield of barley that received 27 lb of K (20 lb Cl) as either KCl or K_2SO_4 or 20 lb Cl as $CaCl_2$ per acre and the control yield.

Canola and Peas

No significant yield increases were obtained with seed-row applied KCl to either canola or peas. In one of the six experiments with canola a significant reduction was obtained with the three fertilizer forms (KCl, $CaCl_2$ and K_2SO_4) suggesting that under the conditions of the experiment applied rates were toxic to the canola seedlings.

Conclusion

Certain barley varieties grown on western Canadian prairie soils containing high "available" potassium levels do respond to seed-row applied KCl every two to three out of five years. We were unable to associate this response with soil Cl levels, root rot infection, crop year, soil type or previous crop. This type of response was a less likely with hard red spring wheat (less than two out of five years) and unlikely with canola and field pea. We were also unable to establish a benefit of seed-row KCl placement on decreasing days to maturity and grain protein or increasing plumpness of malting type barley. A general guideline nomograph based on varying prices of barley and potassium fertilizer (actual lb of K_2O) is provided in Figure 9.

References

Bonczkowski, L.C., R.E. Lamond and D.A. Whitney. 1988. Effects of chloride rates and sources on winter wheat in Kansas. 18th North Central Extension-Industry Soil Fertility Workshop. Nov. 9-10, 1988.

Christensen, N.W., R.G. Taylor, T.L. Jackson and B.L. Mitchell. 1981. Chloride effects on water potentials and yield of winter wheat infected with take-all root rot. Agron. J., 73:1053-1058.

DeJong, E., L. Cowell, P. Flaten, N. Livingston. and C. van Kessel. 1987. Innovative acres 1987 report. Publication No. M86, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, SK.

Engel, R.E. and W.E. Grey. 1991. Chloride fertilizer effects on winter wheat inoculated with *Fusarium culmorum*. Agron. J. 83:204-208.

Fixen, P.E., J.R. Gelderman, J.R. Gerwing and F.A. Cholick. 1986a. Response of spring wheat, barley and oats to chloride in potassium chloride fertilizers. Agron. J. 78:664-668.

Fixen, P.E., G.W. Buchenau, R.H. Gelderman, T.E. Schumacher, J.R. Gerwing, F.A. Cholick and B.G Farber. 1986b. Influence of soil and applied chloride on several wheat parameters. Agron. J. 78:736-740.

Goos, R.J., B.E. Johnson and B.M . Holmes. 1987. Effect of chloride potassium chloride fertilization on two barley cultivars differing in common root rot reaction. Can. J. Plant Sci. 67:395-401.

Goos, R.J., B.E. Johnson and R.W. Stack. 1989. Effect of potassium chloride, imazalil and method of imazalil application on barley infected with common root rot. Can. J. Plant Sci. 69:437-444.

Qian, P., J.J. Schoenau and R.E Karamanos. 1994. Simultaneous extraction of available phosphorus and potassium with a new soi test: A modification of Kelowna extraction. Commun. Soil Sci. Plant Anal. 25:627-635.

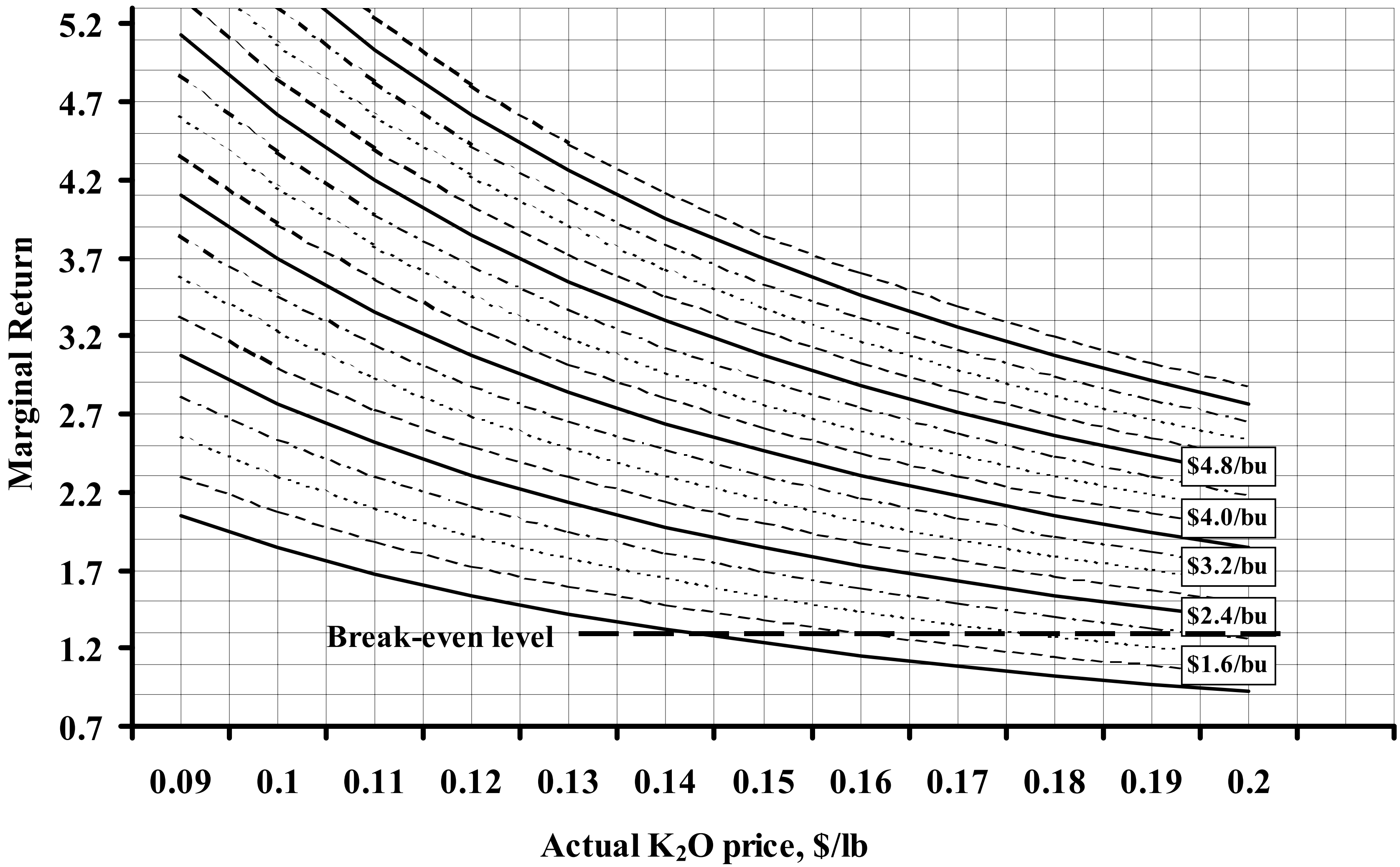

Figure 9. Annualized marginal return ($ return/$1 of K_2O) based on 13 lb seed-placed K_2O per acre based on eight years of continuous K2O application.