SF-25F
1999 - Final

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Applying Research Solutions to Agriculture and the Environment

***TITLE*:**	Field crop response to potassium on soils with high extractable K and varying soil supply rates of K.
***LOCATION*:**	Western Ag Innovations Inc., Saskatoon SK.
***COOPERATORS*:**	Western Ag Innovations Inc., Ken Greer, Principal Catharine MacLeod. IMC Kalium, Mark Bonor

JUSTIFICATION

Response trials from as far back as 1962 indicate that some soils would respond to potassium (K) despite high soil extractable K test levels. "Response to potash is sometimes obtained on soils not deficient in K on the basis of soil test, but at the present time, there is no method of predicting response on these soils." (Western Canada Fertilizer Association, p.12)

Soils (0-6" samples) extracted using ammonium acetate (NH_4OAc) are considered to be very K deficient with 0-150lb ac^{-1} (0-6") extractable K_2O, moderately deficient with 151-250lb ac^{-1} extractable K_2O and marginal to adequate in K fertility with 251-400lb ac^{-1} extracted K_2O. For most crops in Western Canada, no K_2O would be recommended when soil NH_4OAc extractable K_20 exceeds 250lb ac^{-1}. Using conventional soil extraction methods, more than 80% of Saskatchewan would be considered unresponsive to K.

On the other hand, recent widespread use of Plant Root Simulator (PRS™) probes as an assessment of soil K supply rate have shown that only 50 to 60% of soils would be completely unresponsive to K fertilizer. When soil supply rates are used to formulate nutrient management plans with the PRS Nutrient Forecaster™, supply rates lower than 50 μg K $10cm^{-2}$ 24 h^{-1} are considered to be responsive to K fertilizer. Those between 50 and 100 μg K $10cm^{-2}$ $24h^{-1}$ have the potential to respond to K fertilizer depending on other factors influencing plant growth and nutrient demand. Using the Crop Nutrient Forecasting system with the PRS™ probes clearly indicates that environmental conditions greatly impact the probability of a K response.

In conjunction with the Western Ag Innovations Precision Farming study, a wide range of soil types and K supply rates have been measured in Southern Saskatchewan. This area is considered to be generally unresponsive to K fertilizer.

***OBJECTIVE*:** To investigate the potential for a K response in a Southern Saskatchewan field and to compare the abilities of conventional K extraction and K supply rate to predict yield responses to added K.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Applying Research Solutions to Agriculture and the Environment

MATERIALS & METHODS

A study was done in southern Saskatchewan in the 1999-growing season to compare the yield response of flax to 3 rates of applied KCl (0-0-62). Soils were sampled to a 4" depth across the site in spring. The sampling points were geo-referenced using a John Deere Greenstar™ GPS (Figure 1). The soils were analysed for NH_4OAc extractable K (SSSA, p. 568-569) and K supply rate via 24h burial of PRS™ probes (Qian *et al.*, 1998). The soils were also analysed for a wide range of macro- and micronutrient supply rates. Calcium (Ca) and magnesium (Mg) concentrations of the NH_4OAc extracts were measured in an attempt to estimate the relative proportions of the cations in the soil.

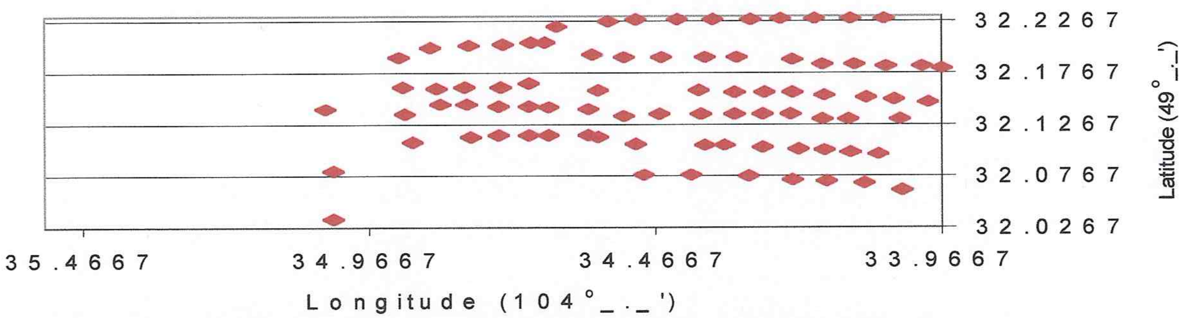

Figure 1. GPS locations of 1999 soil sampling points in NW6-7-19-W2.

The site was seeded and fertilised on June 18, 1999. The seeding rate was 40lb ac^{-1}. Nitrogen, P_2O_5 and S were side-banded at a rate of 40, 30 and 7lb ac^{-1}. KCl was added at rates of 0, 30 and 60lb ac^{-1} along 90' wide strips in the field (Figure 2). Seed and fertilizer placements were performed with a Flexi Coil airseeder with 3 tanks. Application rates were geo-referenced 'on the go' with the JD Greenstar™. The site was harvested on October 9th, 1999. The JD Greenstar™ yield monitor was used to collect yield data at the geo-referenced points during harvest (Figure 3).

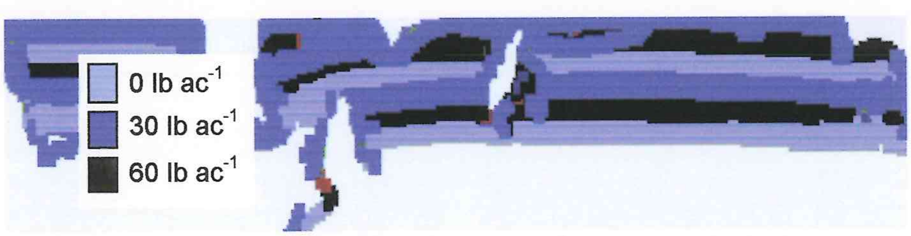

Figure 2. Flexi Coil log viewer map of KCl rates applied to NW6-7-19-W2 in the spring of 1999.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Figure 3. Yield map of flax harvested from NW6-7-19-W2 in the fall of 1999.

RESULTS & DISCUSSION

Comparison of soil K measures

The soils from this field represented a wide range of both extractable K and K supply rates. Extractable K varied from 184-1594lb K ac^{-1} (221-1914lb K_20 ac^{-1}), while K supply rates ranged from 24-293μg K $10cm^{-2}$ $24h^{-1}$. According to K supply rates, 24% of the soils would respond to K addition and another 46% might respond depending on growing conditions. On the other hand, 97% of the sites would not be given a K recommendation based on the extractable K values (WCFA).

The K supply rates were significantly (α=0.01) correlated with the extractable K (Figure 4), however, K supply rates were even more well correlated with the relative ratio of K to other cations (r^2=0.76, α=0.01). This indicates that supply rate is influenced not only by the amount of K in the soil, but also by the ratio of K to other ions. Plants are also influenced by the ratio of ions in the soil – an ion existing in high concentration in the soil may induce deficiency of another ion of lower concentration as the plant takes up a greater amount of the more highly concentrated ion (Bower and Turk, 1946).

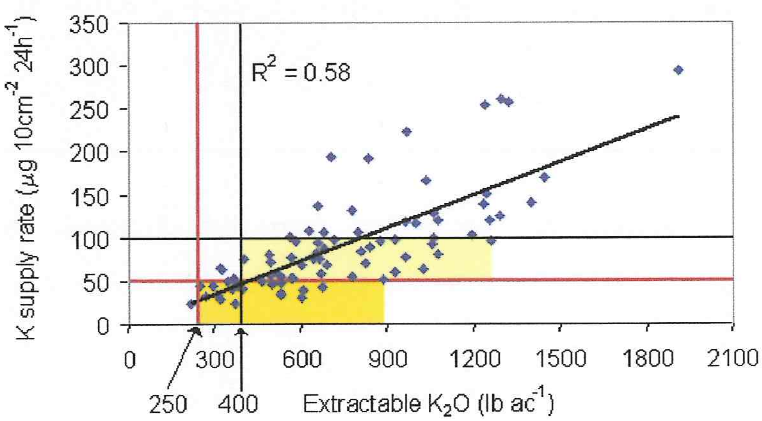

Figure 4. Regression of K supply rates as measured by PRS™ probes with NH_4OAc extractable K.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Thus, it is hypothesised that the PRS™ probes will predict nutrient supplies to plants better than a simple extraction for K, particularly when the relative ratios of cation supply is skewed. This situation often occurs on eroded knolls, where there may be an excess of Ca relative to the other cations. In this situation even though there may be a lot of extractable K, the very high amount of Ca could interfere with K uptake by the plant and the PRS™, resulting in a lower K supply to plant roots and the PRS™.

Yield response to K

Although 82 soil sampling points were established in the field, missing yield and application data meant that only 42 of these points could be used in the comparisons. Of these, 20 were from strips where no KCl was applied, 12 were from strips where 30lb KCl ac^{-1} was applied and 10 were from the 60lb KCl ac^{-1} strips (Figure 5).

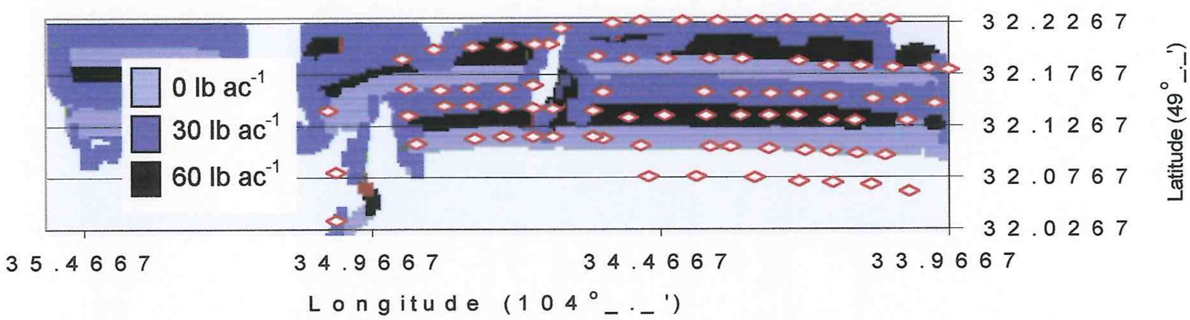

Figure 5. Location of soil sampling points relative to KCl application in NW6-7-19-W2.

Flax yields varied from 2.6bu ac^{-1} to 28.5bu ac^{-1} where the different K rates were applied (Figure 6). Flax yields and soil K were generally poorly correlated (Table 1). The only significant correlation that existed was between PRS™ K supply rates and flax yields at the 0 rate of applied KCl. This correlation was improved further by removing a data point from the field with known salinity (EC=0.57) to r^2=0.36 (significant at α=0.01). The correlation of extractable K with flax yield was improved to 0.004 (not significant) by removing this point. There was no correlation between the relative ratio of extractable K to flax yields. This was likely because the ratio doesn't account for the total amount of K that might be available to the plants. The advantage of the PRS™ supply rate is that it is a functional measure of K^+ ion supply that is sensitive to all cations in proportion to their ionic activities.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

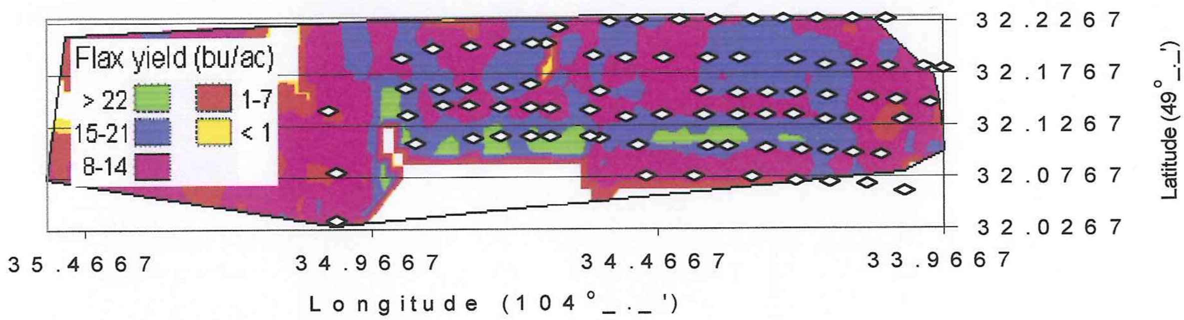

Figure 6. Location of soil sampling points relative to contoured flax yields in NW6-7-19-W2, fall 1999.

Table 1. Correlation coefficients (r^2) for the regression of flax yields (bu ac^{-1}) with measured soil K.

KCl (0-0-62) Application Rate (lb ac^{-1})	NH_4OAc extractable K (lb ac^{-1})	K supply rate (µg $10cm^{-2}$ $24h^{-1}$)
0	-0.0006	0.2040*
30	0.0451	0.0467
60	0.0372	-0.0137

* Significant at α=0.05.

Where KCl was applied, there was no correlation of yields with soil K measured in the spring. The addition of K to these points would eliminate the K deficiency thereby removing any relationship between K supply rate and yields. Screen captures of the PRS Nutrient Forecaster™ for some of these sites show 18lb ac^{-1} K_2O (30lb 0-0-62 ac^{-1}) is enough to move to a relatively flat section of the K response curve for flax (Figure 7).

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Applying Research Solutions to Agriculture and the Environment

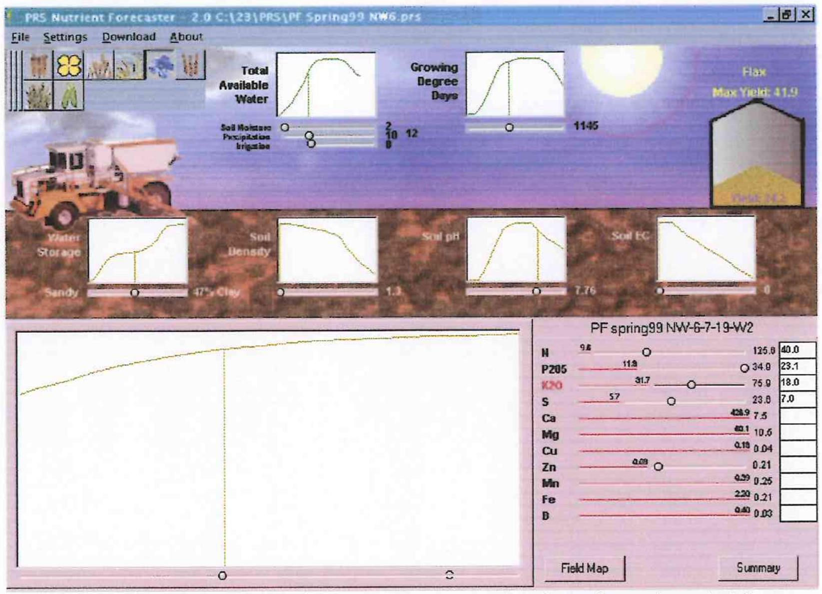

Figure 7. View of the PRS Nutrient Forecaster™ showing the yield response of flax to 18lb K_2O ac^{-1} at a sampling point where the K supply rate was 35.8µg 10cm^{-2} 24h^{-1} and growing conditions were similar to the 1999-growing season.

Since K supply rates were better correlated with flax yields than extractable K was, the next step was to determine how well supply rates could predict a yield response to added K. Preliminary viewing of the JD Greenstar yield map indicated an apparent response to 60lb KCl ac^{-1} as compared to the 0 rate south of it (Figure 8). Although 6 sampling points were located within the 60 rate, a set of 5 sampling points fell on the border between the 0 rate and the 30 rate south of it. Because these sampling points were on the border between the two K rates, it was difficult to determine which fertilizer rate was applied to them with any certainty. The average supply rates between the row of points in the 60 rate and on the border of the 0 and 30 rates were almost identical at 76.5 and 74.6 µg 10cm^{-2} 24h^{-1} and 659 and 631lb extractable K ac^{-1}, respectively.

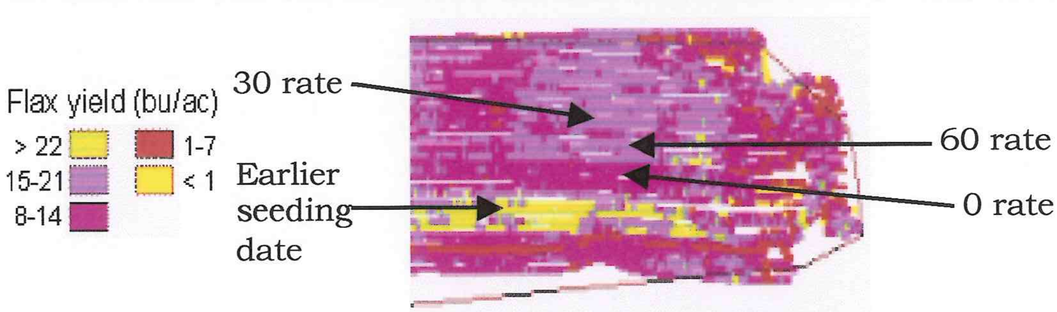

Figure 8. Flax yields harvested from NW6-7-19-W2 in the fall of 1999 indicating possible response to K fertilizer.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

Applying Research Solutions to Agriculture and the Environment

Yield comparisons were made between K application treatments at the specific sampling points via t-tests. The points were separated on the basis of supply rate categories; below 50μg K $10cm^{-2}$ $24h^{-1}$, between 50 and 100μg K $10cm^{-2}$ $24h^{-1}$ and above 100μg K $10cm^{-2}$ $24h^{-1}$. The average flax yields for these ranges at the different treatment rates are given in Table 2.

Table 2. Average flax yields at different KCl (0-0-62) application rates within different supply rate ranges.

KCl Rates	Supply Rate Range (μg K $10cm^{-2}$ $24h^{-1}$)							
	< 50		50 – 100		> 100		< 100	
	Flax yield (bu ac^{-1})	n	Flax yield (bu ac^{-1})	n	Flax yield (bu ac^{-1})	n	Flax yield (bu ac^{-1})	n
0	20.60*	2	11.87	12	18.04	6	13.12	14
30	12.61	3	13.25	5	13.44	4	13.01	8
60	13.94	4	15.87	2	12.50	4	14.58	6

*Yield anomaly created by combine hysteresis.

All yield data used was from the exact points where soil samples were collected in the spring. Inferences about data between the sampling points have not been made at this time, but may be investigated further in the future.

There were no significant responses to K fertilizer at the $\alpha=0.05$ level, however with $\alpha=0.10$, there was a significant difference between flax yields at the 0 and 60 rates of applied KCl at the < 50 and 50-100 μg K $10cm^{-2}$ $24h^{-1}$ supply rate ranges. The yield response was positive to 60lb ac^{-1} KCl at the 50-100 μg K $10cm^{-2}$ $24h^{-1}$ supply rate range, however there were only 2 sampling sites for the 60 rate range. Given the constraints of this precision farming study, sampling points could not be matched exactly with responsiveness of an area and product application. After-the-fact matching of sites and application rates resulted in a limited number of sites that could be analysed and resulted in only tentative conclusions.

There appears to be a negative yield response to K fertilizer at the <50 μg K $10cm^{-2}$ $24h^{-1}$ supply rate. However, yields at the 0 rate were based on 2 sample sites right next to each other in a hummocky area of the field. Combining through a depressional area and up onto a hilltop causes a lag in grain yield monitoring which is a known source of error in yield maps. This lag results in grain cut and partially thrashed in the low area actually reaching the yield monitor when the combine is positioned on the more level, less productive hilltop. Thus, the yields at these two points are likely artificially high. In fact, if these 2 points are removed from the data analysis, the correlation of K supply rates with flax yields actually improves to $r^2=0.68$.

208-111 Research Drive, Saskatoon, SK. CANADA, S7N 3R2
Phone 306-978-1777 Fax 306-978-4140

CONCLUSIONS

There were wide variations in both extractable K and K supply rate across this southern Saskatchewan farm field. Although K extractions indicated there was sufficient K to meet plant demand at most of the sampling points, K supply rates indicated that 24-70% of the field might respond to KCl addition.

K supply rates were significantly correlated to both extractable K levels as well as the ratio of extractable K to the sum of extractable Ca, Mg and K.

Despite the large degree of within field variability, K supply rates were significantly correlated to flax yields. Neither extractable soil K nor the extractable K: other cations ratio were significantly correlated with flax yield.

It appeared that there was a yield response to K on the low K supply rate soils, however this is a tentative conclusion and further research is required to confirm this.

REFERENCES

Bower, C.A. and Turk, L.M. 1946. Calcium and magnesium deficiencies in alkali soils. Amer. Soc. Agron. J. 38: 723-727.

Qian, P., Schoenau, J.J. and Li, G. 1998. Potential soil potassium supply capacity as related to wheat potassium demand. Commun. Soil Sci. Plant Anal. 29: 635-641.

Soil Science Society of America. 1996. Methods of Soil Analysis: Part 3 Chemical Methods. ed. J.M. Bartels. Madison, Wisconsin, U.S.A. p. 568-569.

Western Canada Fertilizer Association. Western Canada Potash Handbook. p. 12.