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MPSG ANNUAL EXTENSION REPORT

PROJECT TITLE: **Soybean Response to Potassium Fertility and Fertilizer in Manitoba**

PROJECT START DATE: 1 April 2017 **PROJECT END DATE: 31 March 2020**

DATE SUBMITTED: April 1 2019

PART 1: PRINCIPAL RESEARCHER

PRINCIPAL

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PART 2: EXECUTIVE SUMMARY

Outline the project objectives, their relevancy to pulse and soybean farmers, and a summary of the project to date, including methods and preliminary results.

Background

Historically, potassium fertility may not have been at the forefront of a typical Manitoba producer's nutrient management concerns given the extent of K-rich clays in the province. However, potassium fertility management is, and will continue to become, demanding of attention – and soybean production has a lot to do with this.

In Manitoba in recent years, there has been a very large and rapid expansion in soybean acres. In fact, soybean now occupies more than a quarter of the province's annual crop land. This expansion, coupled with soybean's high K removal rates in the grain at harvest (1.1 – 1.4 lb K_2O/bu), has changed the total amount of K being removed from Manitoba soils over time. There has been a large increase in the last several years, and the majority of that increase is accounted for by the change in soybean acres. The expansion in acres, high K removal rates and increasing genetic yield potentials likely explain the increase in incidence of K deficiency symptoms in soybeans in recent years, especially as production expands into lighter textured soils that are inherently low in potassium.

According to the Manitoba Soil Fertility Guide, current soybean K fertility recommendations are identical to those for crops such as spring wheat and canola – both of which do not remove K to the same extent as soybean crops (Table 1). In addition, these thresholds and rates are lower than what is currently recommended in neighbouring soybean producing areas such as North Dakota, Minnesota and

Ontario. With the growing prevalence of soybean in Manitoba's crop rotations, the increase in incidence of K deficiency symptoms in soybean and the lack of comprehensive historical research for soybean K fertility in the province, it was time to reassess and update these recommendations.

Table 1. Current potassium fertility recommendations for soybean production according to the Manitoba Soil Fertility Guide

Ammonium Acetate Soil Test K level	Recommendation
>100 ppm	No additional K
50 – 75 ppm	30 kg K_2O/ac broadcast & incorporated
<25 ppm	60 lb K_2O/ac broadcast & incorporated

Research Objectives

1. Determine the frequency of soybean yield response to K fertilizer additions across a range of soil test levels and soil types
2. Assess the effectiveness of different combinations of potash rates and placements, for increasing soybean seed yield
   I. 30 or 60 lb K_2O/ac sidebanded
   II. 30, 60 or 120 lb K_2O/ac broadcast and incorporated
3. Investigate the capacity for MB soils to retain added K in non-exchangeable forms, which may not be available for crop uptake

Methods

In addition to the four site years in 2017, three site years were established in the 2018 field season. The background ammonium acetate exchangeable K levels for these sites can be found in Table 2. The target range for these K rate and placement studies was soils with spring soil test potassium levels <100 ppm, which is the current threshold for recommending an application of K fertilizer on soybeans in MB.

Table 2. Background spring soil test ammonium acetate K (STK) levels for all site-years

Site Year	Spring Background NH_4OAc STK
Elm Creek 2017	101
Haywood 2017	61
St. Claude 2017	96
Portage la Prairie 2017	62
Haywood 2018	117
Long Plain 2018	95
Bagot 2018	59

Six combinations of potash (KCl) rates and placements were replicated four times at each site:

- 0 lb K_2O/ac (control)
- 30 and 60 lb K_2O/ac, side-banded
- 30, 60 and 120 lb K_2O/ac broadcast and incorporated

Small plots (3m x 8m) were established with a John Deere 1755 4-row precision planter, with the capability to side-band 2” beside and 2” below the seed row. The variety planted was DKB005-52, with a target plant stand of 150 000 plants/ac.

Preliminary Results

Soil Test K: moist or dry soil?

Soil samples taken from each control plot at the time of planting, from a 0-6” and 6-12” depth, were analyzed for ammonium acetate extractable K. Each sample was split into two subsamples; one was kept field-moist, the other was air dried and ground. The differences between K analyzed for moist soil compared to a dried soil were inconsistent and often large. Also, samples varied substantially among replicate control plots within the same site. The moist K to dry K ratio was generally greater than one (Figure 1), indicating greater exchangeable ammonium acetate released from a moist soil compared to a dried soil.

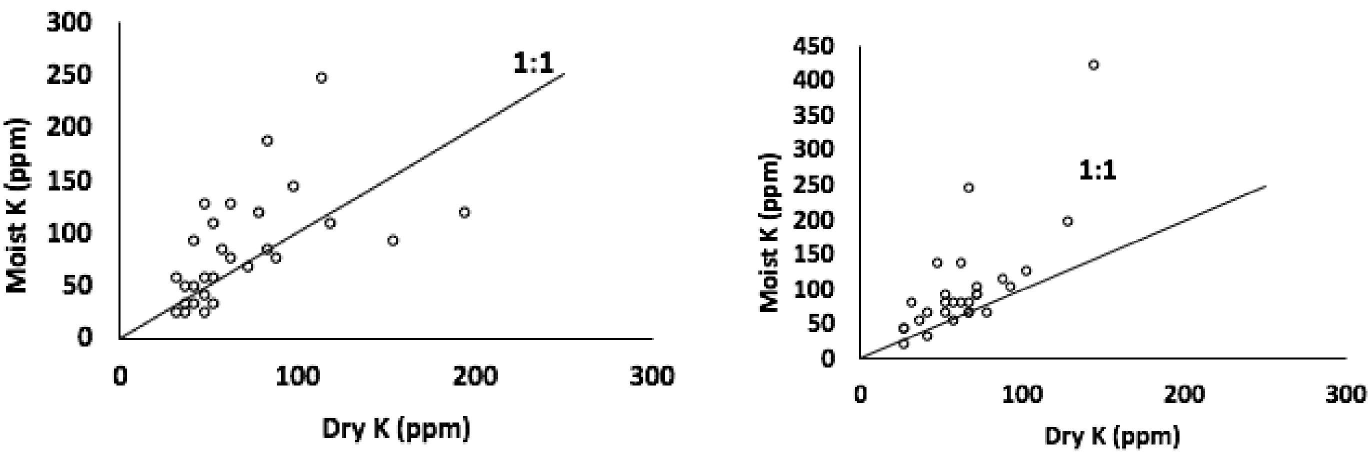

Figure 1. Ratio of ammonium acetate soil test K at planting determined on a moist soil basis and a dry soil basis for a 0-6” sampling depth (left) and a 6-12” sampling depth (right)

In-Season Observations

Several plots at multiple sites in 2017 and 2018 showed characteristic K deficiency symptoms of soybeans including interveinal chlorosis, beginning at the leaf margins of lower leaves. Symptoms first appeared, at some locations, at V2-V3 stage. Later season symptoms were observed at the time of seed fill.

Midseason Tissue Samples

Midseason tissue samples were taken at R2 from each plot and included:

- 10 whole plants per plot (used to determine K uptake)
- 25 uppermost mature trifoliate leaves (to determine if K levels are within the established critical range for this stage)
- 25 stem pieces, from directly above the sampled trifoliate (assessed for K concentration to determine if this is a more sensitive indicator of K nutrition status of the plant than leaf K concentration)

Two of seven site years had significant differences in K concentration between treatments for whole plant, leaf and stem samples. In most cases, the control K concentration fell below or within established critical ranges. Some K treatments, particularly higher rates for both placements, were able to reduce the threat of deficiency, raising the concentration above the critical range. Higher rates of K generally increased tissue K concentrations, but most differences between fertilized treatments, including placements, were not significant. The effect of fertilizer treatment on K uptake was consistent across site years, and the high rate sidebanded treatment was the only treatment where K uptake was greater than uptake in the control (Figure 2).

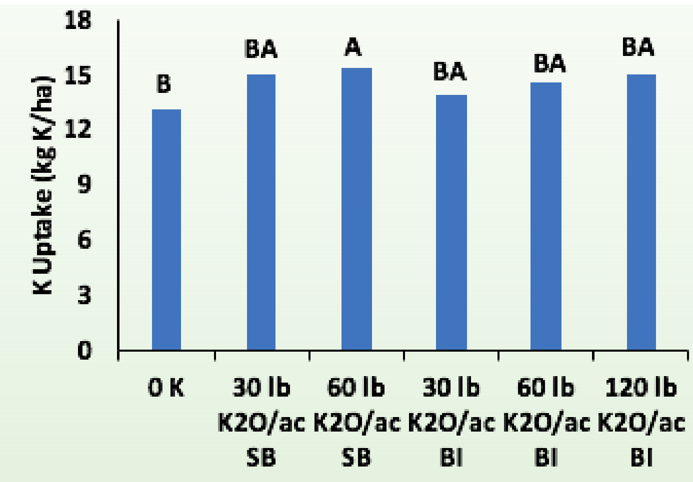

Figure 2. Differences in K uptake between rate/placement treatments, combined data for all 7 site years (treatments with the same letter at the top of the bar are not significantly different at a probability threshold of p=0.05 or less)

Table 2. Global analysis of variance (ANOVA) for K uptake

Effect	F Value	Pr>F
Treatment	3.03	0.0134
Site year	11.01	<0.0001
Site year * Treatment	1.06	0.3958

Seed Yield, K Concentration, Oil & Protein Content

Average seed yield from the small plot sites was 29 bu/ac in 2017 and 18 bu/ac in 2018. Lack of moisture was generally a yield limiting factor at these sites in both field seasons, especially due to the sandy soil texture that typical for these low K sites. No significant yield responses were found to any treatment at any site. The lack of yield response was surprising, especially given the low background STK levels at these sites, and the presence of deficiency symptoms. There was no agronomically or statistically meaningful relationship found between background ammonium acetate STK and relative yield regardless of placement and rate. No meaningful relationship between background levels and yield were identified regardless of method of ammonium acetate extraction, on a moist or dry basis (Figure 3).

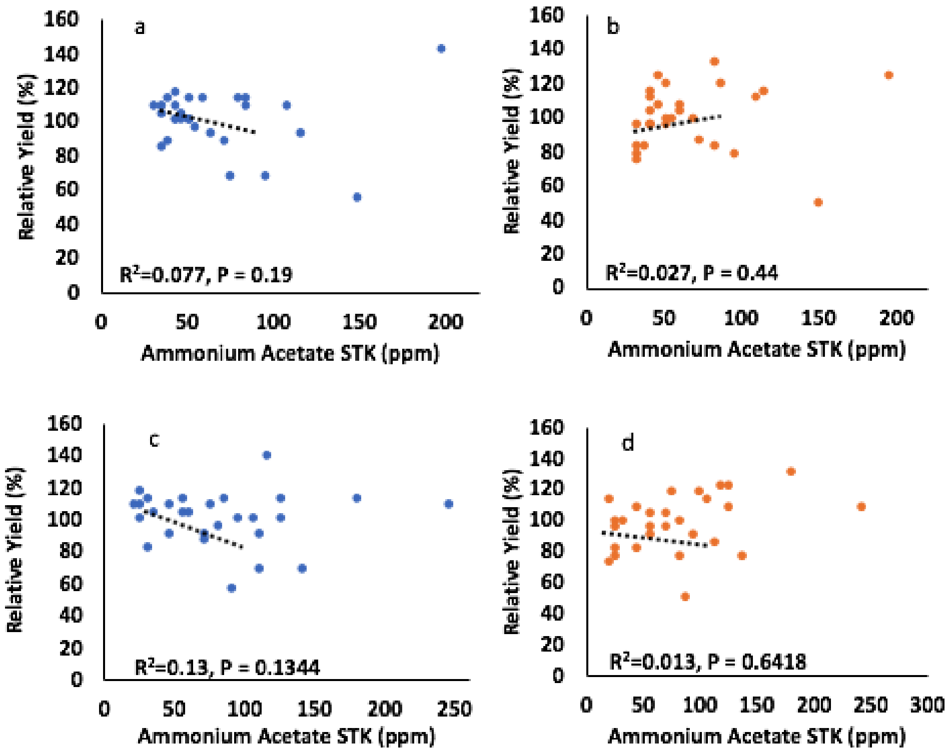

Figure 3. Relationship between ammonium acetate soil test K and relative yield for a broadcast and incorporated treatment (120 lb K_2O/ac) and a sidebanded treatment (60 lb K_2O/ac) when ammonium acetate K was assessed on dry soil samples (top) and moist soil samples (bottom)

The pattern of seed K concentration response to fertilizer treatment was similar to K uptake. Seed K concentration generally increased with higher rates of K for both placements (Figure 4). There was no effect of treatment on oil or protein content.

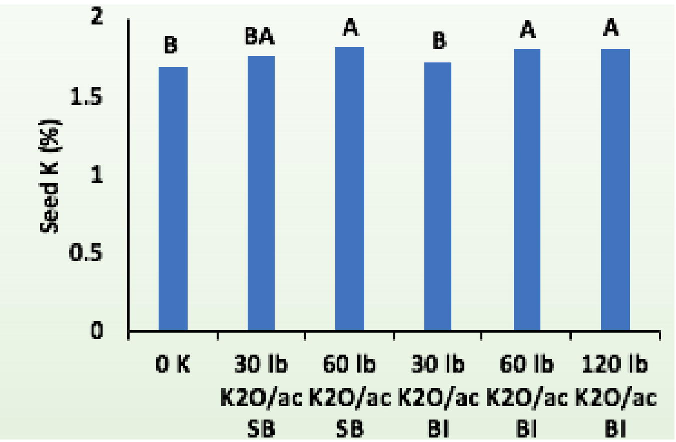

Figure 4. Differences in seed K concentration between rate/placement treatments, combined data for all 7 site years (treatments with the same letter at the top of the bar are not significantly different at a probability threshold of p=0.05 or less)

Table 3. Global analysis of variance (ANOVA) ANOVA for seed K

Effect	F Value	Pr>F
Treatment	6.41	<0.0001
Site year	6.42	0.0006
Site year * Treatment	1.16	0.2813

On-Farm Trials

The on-farm trials were established in conjunction with the MB Pulse and Soybean Growers On-Farm Network to characterize yield response across a range of STK levels. In total, 20 site-years were established with background ammonium acetate exchangeable STK levels ranging from 52-235 ppm. Each site was a replicated strip trial with one treatment of either 60 lb K_2O/ac banded away from the seed, or 120 lb K_2O/ac broadcast and incorporated. Treatment strips were randomized and replicated along with untreated control strips.

Three of twenty sites responded statistically significantly, two being yield increases and one a yield decrease (Figure 5). Only two significant positive responses were found. While one of these positive responses was at a site that had a background STK level less than 100 ppm, the current threshold for recommending an application of K fertilizer, the other was at a site that had well over this level of K in the soil. A higher frequency of response was expected, with more positive responses being anticipated at the sites that were at, or below, 100 ppm STK.

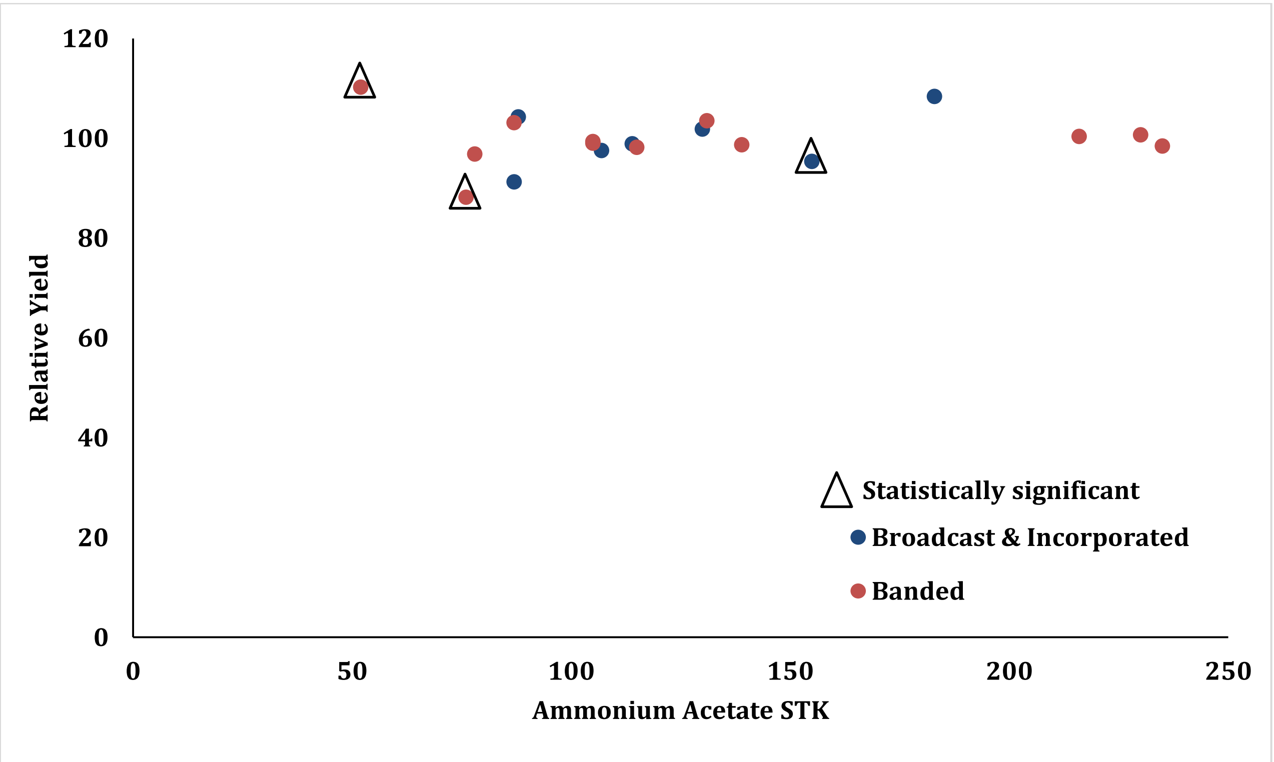

Figure 5. On-farm trial relative yield in relationship to background ammonium acetate extractable soil test K (STK) levels

Acknowledgements

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PART 3: PROJECT ACTIVITIES AND PRELIMINARY RESULTS

Outline project activities, preliminary results, any deviations from the original project and communication activities. You may include graphs/tables/pictures in the Appendix.

Overall, the project has progressed as expected. Both field seasons have been completed, and results are summarized in part 2. The lab experiment investigating K retention capacity of the soils from field sites is in progress.

In addition to the 2017 project activities:
Potassium fertility for soybean production was discussed in collaboration with MPSG staff at the Arborg and Melita SMART days in July 2018. Results from the project have been presented through posters at the North-Central Soil Fertility Conference in Iowa, November 2018, the Manitoba Agronomists Conference in Winnipeg, December 2018 and the Manitoba Soil Science Society meetings in Winnipeg, February 2019. Oral presentations were given at the American Society of Agronomy/Canadian Society of Agronomy meeting in Baltimore, November 2018 and the Soil Science Society of America meetings in San Diego, January 2019, the Manitoba Soil Science Society meeting in Winnipeg, February 2019 and the Agvise seminar in Portage la Prairie, March 2019. An article was written for the spring 2019 edition of the Pulse Beat magazine and the research project was featured in the Top Crop Manager article in February 2019. Photos of the project are available upon request.

APPENDIX

Include up to 1 page of tables, graphs, pictures.

A secondary study was developed for the 2018 field season, based on the results from 2017. To investigate potential mechanisms leading to the lack of soybean yield response to K addition on low-K sites, a barley soybean K responsiveness comparison study was developed. The main objective was to determine if barley, which is known to respond quite well to K fertilizer additions in Manitoba, was responding differently to K fertilizer treatment than soybean. The study was a split plot design, with crop as the main plot and fertilizer as the subplot (no K fertilizer added or 120 lb K_2O/ac added). There was a significant increase in barley yield with the addition of K fertilizer, but there was no difference in soybean yield (Figure 6).

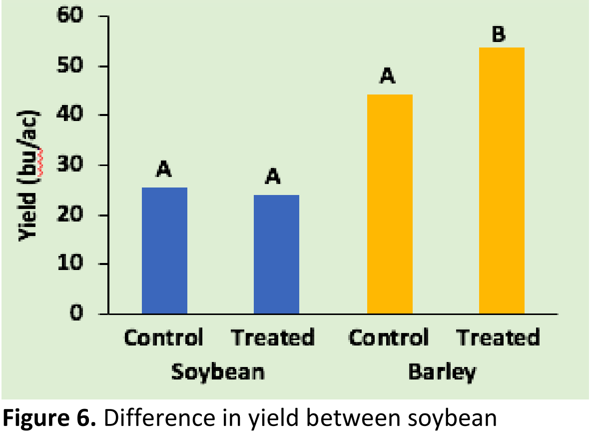

Figure 6. Difference in yield between soybean with and without 120 lb K_2O/ac, and barley with and without 120 lb K_2O/ac across three site years