2021 Final Research Report

from the

Saskatchewan Oat Development Commission

Project Title: Are Oats Responding to Higher Levels of Macronutrients?

(ADOPT # 20200484)

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Project Identification

1. **Project Number:** ADOPT # 20200484
2. **Producer Group Sponsoring the Project:** Saskatchewan Oat Development Commission
3. **Project Location(s):** Yorkton, Indian Head, Melfort and Redvers, Saskatchewan
4. **Project start and end dates (month & year):** April 2021 to February 2022
5. **Project contact person & contact details:**

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Objectives and Rationale

6. **Project objectives:**

The objective of this project was to demonstrate the response of a modern oat variety to the historically recommended rate of 60 lb N/ac against the more recent recommendation of 90 lb N/ac and to determine the relative importance of combining phosphorus (P), potassium (K) and sulphur (S) with these different nitrogen (N) recommendations in eastern Saskatchewan. The influence of treatment on oat yield, lodging and test weight were determined.

7. **Project Rationale:**

There are a substantial number of oat producers that only apply 60 lb N/ac or less. This may be the right thing to do particularly for those that seed oats late; however, recent research using modern varieties of oats suggests that this rate is on the low side. High yielding oat varieties that maintain adequate test weights at higher rates of N are available. The results of this demonstration may encourage producers who still apply low rates of N, to test those long held assumptions with strips of higher N rates in their fields. Adding higher rates of PKS may also have more importance in conjunction with higher rates of N. Producers have the most experience with their land but varieties change and it is worth regularly testing these long held assumptions.

Methodology and Results

8. **Methodology:**

At each location, the trial was setup as a factorial with 4 replications and was designed to determine the response of oats to increasing rates of N (second factor) under 4 different combinations of added PKS (first factor). The four PKS fertility regimes used were as follows:

1. Full rates of PKS (40 lb P_2O_5/ac + 15 lb K_2O + 10 lb S/ac)

2. Sulphur limited-Full rates of PK (40 lb P_2O_5/ac + 15 lb K_2O)

3. Potassium Limited-Full rates PS (40 lb P_2O_5/ac + 10 lb S/ac)

4. Phosphorus Limited-Full rates of KS (15 lb K_2O + 10 lb S/ac)

Contributions of N from phosphorus and sulphur sources were balanced, so that total rates of N of 17, 60 and 90 lb/ac were evaluated for each PKS fertility regime. Factorial treatments along with a check where no fertilizer was applied are listed in Table 1. The check is not part of the factorial design but has been included for comparison without being part of the statistical analysis. Plot size varied by site based on available equipment but was approximately 11 by 30 ft. Where possible, only the middle sections of plots were harvested with small plot combines to avoid edge effects. CDC Arborg oats were seeded to target 300 viable seeds/m^2. Dates of key operations for each site are listed in Table 2 and soil test results are presented in Table 3.

Table 1. Treatment List for "Are oats responding to higher levels of macronutrients?" trial

Trt#	**Seed-placed box 1**	**Side-band box 1**	**Side-band box 2**	**Total N**
1	none	none	none	
Nitrogen response with full rates of PKS				
2	40 lb P_2O_5/ac	15 lb K_2O/ac + 10 lb S/ac	0 lb N/ac	17 lb/ac
3	40 lb P_2O_5/ac	15 lb K_2O/ac + 10 lb S/ac	43 lb N/ac	60 lb/ac
4	40 lb P_2O_5/ac	15 lb K_2O/ac + 10 lb S/ac	73 lb N/ac	90 lb/ac
Nitrogen response with Sulphur limitation				
5	40 lb P_2O_5/ac	15 lb K_2O/ac	8.5 lb N/ac	17 lb/ac
6	40 lb P_2O_5/ac	15 lb K_2O/ac	51.5 lb N/ac	60 lb/ac
7	40 lb P_2O_5/ac	15 lb K_2O/ac	81.5 lb N/ac	90 lb/ac
Nitrogen response with Potassium limitation				
8	40 lb P_2O_5/ac	10 lb S/ac	0 lb N/ac	17 lb/ac
9	40 lb P_2O_5/ac	10 lb S/ac	43 lb N/ac	60 lb/ac
10	40 lb P_2O_5/ac	10 lb S/ac	73 lb N/ac	90 lb/ac
Nitrogen response with Phosphorus limitation				
11	None	15 lb K_2O/ac + 10 lb S/ac	8.5 lb N/ac	17 lb/ac
12	None	15 lb K_2O/ac + 10 lb S/ac	51.5 lb N/ac	60 lb/ac
13	None	15 lb K_2O/ac + 10 lb S/ac	81.5 lb N/ac	90 lb/ac

Table 2. Dates of operations in 2021 for the "Are Oats Responding to Higher Levels of Macronutrients?" trial				
Activity	**----------Date----------**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
Pre-seed Herbicide Application	May 11 (Roundup Weathermax)	May 14 (Glyphosate + Heat)	None	None
Seeding	May 7	May 12	May 11	May 4
Emergence Counts	June 7	June 4	June 4	May 27
In-crop Herbicide Application	June 13 (Prestige XL)	June 18 (Prestige XC)	June 1 (Buctril M)	June 7 (Prestige)
Lodging Rating	Aug 5	Aug 16 (None)	None	
Date of Maturity	Aug 2	July 30	Aug 4	July 26
Harvest	Aug 16	Aug 16	Aug 31	Aug 12

Table 3. Soil Test Results for the "Are Oats Responding to Higher Levels of Macronutrients?" trial				
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
Nitrogen (lb N/ac)				
0-6"	8	35	17	
6-12"	10	22		
6-18"			33	
0-12"				74
12-24"	10			18
Phosphorus Olsen (ppm)	12	7	3	6
Potassium (ppm)	671	502	194	213
Sulfur (lb/ac)	22 (0-6")	14 (0-6")	54 (0-6")	128 (0-12")

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts with long term (1981-2010) averages for 4 sites are listed in Tables 4 for the 2021 growing season. The 2021 season was warm at all locations. Seasonal precipitation was quite low at Yorkton and Melfort were levels were only 54% and 61% of the long-term average, respectively.

Table 4. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) normals for the 2021 growing seasons at 4 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		----------*Mean Temperature (°C)* ----------				
Indian Head	2021	9.0	17.7	20.3	17.1	16.0
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Melfort	2021	9.6	18.2	20.1	16.9	16.2
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
	Long-term	***10.4***	***15.3***	***18.0***	***16.7***	***15.1***
Redvers	2021					
	Long-term	***12***	***16***	***19***	***18***	***16.3***
Yorkton	2021	8.9	19.1	21.0	17.3	16.5
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
		---------- *Precipitation (mm)* ----------				
Indian Head	2021	81.6	62.9	51.2	99.4	295.1
	Long-term	***51.7***	***77.4***	***63.8***	***51.2***	***241.4***
Melfort	2021	31.4	37.6	0.2	69.3	138.5
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***
Redvers	2021					
	Long-term	***60***	***91***	***78***	***64***	***293***
Yorkton	2021	24.6	18.1	35.2	69.7	147.6
	Long-term	***51***	***80***	***78***	***62***	***272***

Crop emergence varied between locations, averaging 268, 167, 348 and 239 plants/m^2 at Yorkton, Melfort, Indian Head and Redvers, respectively. Interactions between the level of PKS and N rate were not significant at any site, allowing the discussion to focus on main effects only. Levels of PKS did not affect emergence at any location except Yorkton, where emergence was significantly higher when potassium was left out of the blend (Table 4). However, it is unclear if the potassium truly caused emergence issues as the no fertilizer check numerically had the lowest count. Salt effects from the potash may have reduced emergence, but would not have been anticipated with side-banded potash. Increasing N from 17 to 90 lb/ac significantly increased emergence at Redvers, which is also unusual. However, increasing N had no significant effect on emergence at the other sites. Overall, the magnitude of significant differences in emergence were not large and were unlikely to have a substantial effect on yield.

Levels of PKS did not significantly affect maturity at any location except for Indian Head, where the phosphorus limitation treatment delayed maturity (Table 5). While the effect was very small, less than a day, it does make sense as phosphorous deficiency is known to delay maturity. Increasing N rate from 17 to 90 lb/ac also significantly delayed maturity at Melfort and Redvers. The delay of 5 days was substantial at Redvers. At Indian Head, 90 lb N/ac delayed maturity relative to 60 lb N/ac but not relative to 17 lb N/ac. This is a little counter intuitive and must be attributed to random variation. At Yorkton, increasing N did not significantly affect maturity. No significant interactions between the level of PKS and N rate were detected or needed further investigation.

Lodging was not an issue at any of the sites and no statistically significant effects between treatments were detected (Table 6).

Yield potentials varied greatly between sites. Indian Head and Melfort were relatively high yielding sites with maximum yields averaging 3720 kg/ha (98 bu/ac) and 3990 kg/ha (105 bu/ac), respectively. Maximum yield at Redvers averaged 3200 kg/ha (84.2 bu/ac) and Yorkton was the lowest yielding site at only 2300 kg/ha (60 bu/ac) due to drought. Statistically significant yield responses to added fertility were detected at all locations (Table 7). However, no interactions between the levels of PKS and nitrogen rate were detected. In other words, the effect of added P, K, or S on yield did not differ between rates of N. Again, this allows the focus to be on the main effects.

Focusing on levels of PKS, the phosphorus limited treatment produced the lowest yield at Indian Head, Melfort and Redvers, suggesting a yield response to added phosphorus. While the phosphorus limited treatment at Indian Head was not statistically lower yielding than the PKS check, it was significantly lower than the sulphur limited treatment, suggesting a weak response to added phosphorus. At Melfort, the positive yield response to added phosphorus was clear, as the phosphorus limited treatment was significantly lower yielding than all other treatments. Unexpectedly, the potassium limited treatment was significantly higher yielding than the full rate of PKS at Melfort. Providing a reasonable explanation for this is a challenge and the difference may be

solely the result of random variation. Salt effects from potash could have been detrimental to plant establishment; however, this would not be anticipated as the potash was in the side band and not seed placed. Moreover, detrimental effects of potash on seedling emergence were not observed (Table 4). At Redvers, the phosphorus limited treatment was also the lowest yielding treatment and, similarly to the results from Indian Head, was not significantly different from the full rate of PKS but was statistically lower than the sulphur and potassium limited treatments. Again, it is difficult to account for this, but the data does suggest a yield response to added phosphorus. At Yorkton, the yield for the phosphorus limited treatment was lower than the full PKS check but the difference was not significant. However, the site did prove to be significantly responsive to added sulphur and potassium. The response to sulphur was unexpected considering the high residual soil S and low yields.

Focusing on N responses, yields did not significantly respond to added N at Redvers or Yorkton. However, very modest numerical increases with the addition of 60 lbs N/ac did occur at both locations. At Melfort, yield was significantly increased by adding 60 lbs N/ac, but yield did increase further in response to 90 lb N/ac. The Indian Head site was quite responsive to added N with the yield of all N rates significantly differing from each other. Increasing N from 17 to 90 lb/ac increased yield at Indian Head by 23%. The Indian Head site was responsive to added N because residual levels of N were low (Table 3) and the yield potential was relatively high.

For the test weight data, the lack of interactions at any site allows for the focus to be on main effects. Test weights significantly declined in response to added N at Indian Head and Redvers (Table 8). Numerically, test weight also declined in response to added N at Yorkton ($P<0.1$) and Melfort. Overall, test weights were quite low at Redvers and Yorkton. Even with only 17 lb N/ac, the test weight at Yorkton was well below Grain Miller's rejection level of 230 g/0.5 l for milling oat. At Redvers, the higher rates of N also pushed test weights below this rejection level. Test weights at Indian Head and Melfort were much higher and the oats would have been acceptable for milling at any rate of N. The application of P, K, or S did not significantly affect test weight. In other words, the application of P, K, or S did not help to maintain any loss in test weight associated with increasing N.

10. Conclusions and Recommendations

In conclusion, the optimum rate of N to maximize yield, but still maintain an adequate test weight, varied between locations. While Indian Head, Melfort and Redvers were responsive to added phosphorus and Yorkton was responsive to added potassium and sulphur, the optimum rate of N was not influenced by the addition of P, K, or S as there were no significant interactions. The only site to require the addition of 90 lb N/ac was Indian Head. At this rate the yield was maximized and test weights were still acceptable, albeit discounted. The optimum rate at Yorkton was only 17 lb N/ac because of low yield potential due to drought and high residual levels of background nitrogen. Moreover, test

weights at this location were well below the rejection level regardless of N rate. The Redvers site only required the application of 17 lb N/ac as well. While 60 lb N/ac provided the highest numeric oat yield at this location, it also pushed test weights below the acceptable range for milling. At Melfort, 60 lb N/ac was the optimum rate to significantly maximize yield and still maintain adequate test weight. Treatment effects on lodging and maturity were either insignificant or not of agronomic concern.

Supporting Information

11. Acknowledgements:

This project was funded by the Agricultural Demonstration of Practices and Technologies (ADOPT) and Saskatchewan Oat Development Commission.

12. Appendices

Table 4. Main effects of fertilizer on oat emergence at multiple locations in 2021.				
Main effect	**Emergence (plants/m^2)**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
No Fertilizer	347.8	149.0	205	247.0
Levels of PKS				
Full rates of PKS (40 lb P2O5/ac + 15 lb K2O + 10 lb S/ac)	346.9 a	175.1 a	248.5 a	259.5 b
Sulphur limited-Full rates of PK (40 lb P2O5/ac + 15 lb K2O)	350.0 a	173.6 a	252.2 a	267.2 b
Potassium Limited-Full rates PS (40 lb P2O5/ac + 10 lb S/ac)	341.0 a	161.2 a	239.8 a	298.2 a
Phosphorus Limited-Full rates of KS (15 lb K2O + 10 lb S/ac)	354.1 a	176.8 a	239.4 a	269.3 b
LSD	NS	NS	NS	27.4
P-values[z]	NS	NS	NS	0.038
Nitrogen Rate				
17 lb N/ac	357.3 a	173.1 a	234.9 b	266.8 a
60 lb N/ac	347.4 a	173.1 a	245.3 ab	269.3 a
90 lb N/ac	339.3 a	168.9 a	254.8 a	284.6 a
LSD	NS	NS	14.6	NS
P-values[z]	NS	NS	0.32719	NS
[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability				

Table 5. Main effects of fertilizer on oat date of maturity at multiple locations in 2021.				
Main effect	**Date of Maturity (Julian)**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
No Fertilizer	215.5	219.5	216.0	207.0
Levels of PKS				
Full rates of PKS (40 lb P2O5/ac + 15 lb K2O + 10 lb S/ac)	213.6 b	217.3 a	215.5 a	207.4 a
Sulphur limited-Full rates of PK (40 lb P2O5/ac + 15 lb K2O)	213.8 b	216.8 a	215.7 a	206.7 a
Potassium Limited-Full rates PS (40 lb P2O5/ac + 10 lb S/ac)	213.8 b	217.3 a	215.4 a	206.9 a
Phosphorus Limited-Full rates of KS (15 lb K2O + 10 lb S/ac)	214.3 a	219.6 a	215.9 a	208.0 a
LSD	0.36	NS	NS	NS
P-values[z]	0.011892	NS	NS	NS
Nitrogen Rate				
17 lb N/ac	214.0 a	214.9 b	215.3 b	207.5 a
60 lb N/ac	213.6 b	218.4 a	215.4 b	207.2 a
90 lb N/ac	214.1 a	219.9 a	216.2 a	207.1 a
LSD	0.31	2.0	0.7	NS
P-values[z]	0.004815	0.000047	0.038526	NS
[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability				

Table 6. Main effects of fertilizer on oat lodging at multiple locations in 2021.				
Main effect	**Lodging (0-10)**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
No Fertilizer	1.0	1.0	1.0	0.5
Levels of PKS				
Full rates of PKS (40 lb P2O5/ac + 15 lb K2O + 10 lb S/ac)	1.0 a	1.0 a	1.0 a	1.0 a
Sulphur limited-Full rates of PK (40 lb P2O5/ac + 15 lb K2O)	1.1 a	1.0 a	1.0 a	0.7 a
Potassium Limited-Full rates PS (40 lb P2O5/ac + 10 lb S/ac)	1.1 a	1.0 a	1.0 a	0.7 a
Phosphorus Limited-Full rates of KS (15 lb K2O + 10 lb S/ac)	1.0 a	1.0 a	1.0 a	0.3 a
LSD	NS	NS	NS	NS
P-values[z]	NS	NS	NS	NS
Nitrogen Rate				
17 lb N/ac	1.0 a	1.0 a	1.0 a	0.5 a
60 lb N/ac	1.1 a	1.0 a	1.0 a	0.7 a
90 lb N/ac	1.1 a	1.0 a	1.0 a	0.8 a
LSD	NS	NS	NS	NS
P-values[z]	NS	NS	NS	NS

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 7. Main effects of fertilizer on oat yield at multiple locations in 2021.				
Main effect	**Yield (kg/ha @ 13.5%)**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
No Fertilizer	2456.5	3271.0	2471.1	2334.5
Levels of PKS				
Full rates of PKS (40 lb P2O5/ac + 15 lb K2O + 10 lb S/ac)	3463.7 ab	3958.8 b	3027.5 ab	2467.0 a
Sulphur limited-Full rates of PK (40 lb P2O5/ac + 15 lb K2O)	3519.3 a	3980.6 ab	3258.5 a	2121.7c
Potassium Limited-Full rates PS (40 lb P2O5/ac + 10 lb S/ac)	3406.8 ab	4089.1 a	3235.8 a	2166.3 bc
Phosphorus Limited-Full rates of KS (15 lb K2O + 10 lb S/ac)	3363.2 b	3621.0 c	2815.3 b	2356.8 ab
LSD	112.9	115.9	298.0	212.2
P-values[z]	0.87713	0.000108	0.045984	0.029038
Nitrogen Rate				
17 lb N/ac	3024.6 c	3767.1 b	2918.3 a	2276.9 a
60 lb N/ac	3567.9 b	3989.8 a	3207.2 a	2305.3 a
90 lb N/ac	3722.2 a	3980.3 a	3127.4 a	2251.6 a
LSD	97.8	100.4	NS	NS
P-values[z]	<0.00001	0.000077	NS	NS

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 8. Main effects of fertilizer on oat test weight at multiple locations in 2021.				
Main effect	**Test Weight (g/0.5L)**			
	Indian Head	**Melfort**	**Redvers**	**Yorkton**
No Fertilizer	242.9	251.4	241.0	240.9
Levels of PKS				
Full rates of PKS (40 lb P2O5/ac + 15 lb K2O + 10 lb S/ac)	242.7 a	249.5 a	231.8 a	216.7 a
Sulphur limited-Full rates of PK (40 lb P2O5/ac + 15 lb K2O)	242.8 a	249.5 a	231.3 a	215.8 a
Potassium Limited-Full rates PS (40 lb P2O5/ac + 10 lb S/ac)	242.9 a	248.5 a	232.8 a	214.6 a
Phosphorus Limited-Full rates of KS (15 lb K2O + 10 lb S/ac)	241.1 a	246.8 a	230.8 a	219.8 a
LSD	NS	NS	NS	NS
P-values[z]	NS	NS	NS	NS
Nitrogen Rate				
17 lb N/ac	243.9	250.2 a	237.9 a	218.7 a
60 lb N/ac	241.7	248.0 a	229.8 b	216.9 a
90 lb N/ac	241.5	247.5 a	227.5 b	214.5 a
LSD	1.39	NS	3.8	NS
P-values[z]	0.002213	NS	<0.00001	0.086
[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability				

Abstract

13. Abstract/Summary:

Trials were conducted at Yorkton, Indian Head, Melfort and Redvers to demonstrate the response of a modern oat variety to the historically recommended rate of 60 lb N/ac against the more recently suggested recommendation of 90 lb N/ac. The trials were also designed to determine the relative importance of adding phosphorus (P), potassium (K) and sulphur (S) for these different nitrogen (N) recommendations in eastern Saskatchewan. The optimum rate of N, to maximize yield and still maintain acceptable test weights for milling, varied between locations. While Indian Head, Melfort and Redvers were responsive to added phosphorus and Yorkton was responsive to added potassium and sulphur, the optimum rate of N was not influenced by the addition of P, K, or S as there were no significant interactions. Only 17 lb N/ac were required at Yorkton and Redvers. Higher rates did not significantly increase yields at these locations, and in the case for Redvers, increasing N pushed test weights down below the acceptable level for milling. At Yorkton, test weights were well below the acceptable level for milling at all rates of applied N. The low yield response to added N at Yorkton can be attributed to low yield potential due to drought and high residual soil N. At Melfort, 60 lb N/ac was the optimum rate and 90 lb N/ac was the optimum rate at Indian Head. Treatment effects on lodging and maturity were either insignificant or not of agronomic concern.