2023 Research Report

from the

East Central Research Foundation

Project Title: SaskOats – Oat N Response

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Project Identification

1. **Project Number:** POGA 2
2. **Producer Group Sponsoring the Project:** Saskatchewan Oat Development Commission
3. **Project Location(s):** Yorkton, SK, Outlook, SK, Melfort, SK, and Prince Albert, SK.
4. **Project start and end dates (month & year):** April 2023 to February 2024
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Objectives and Rationale

6. **Project objectives:**

To determine the yield and test weight response of Oats to 15% and 30% reductions in recommended rates of N. The specific rates of soil + fertilizer N tested will be 125 lb/ac, 106 lb/ac, 88 lb/ac and no applied N.

Methodology and Results

7. **Methodology:**

Trials were established at each location as a factorial Design with only 2 replicates. It should be noted that having only 2 replications instead of the conventional 4 replicates greatly reduces the power to detect significant differences. The first factor contrasted CS Camden vs CDC Arborg oats and the second factor compared each of these varieties at 4 rates of soil + applied N (Table 1). Background soil N (0 to 24") for treatments 1 and 5 varied from a low of 20 lb N/ac at Outlook to a high of 57 lb N/ac at Melfort (Table 1). All treatments received 40 lb P_2O_5/ac + 15 lb K_2O/ac + 10 lb S/ac so that PKS were non-limiting to yield. All trials are considered "small plot" in design but plot size varied between sites to suit site equipment. Plots were harvested with small plot combines and yield was adjusted for moisture. Test weights were determined "in house" at each location. After harvest, each treatment (averaged over rep) was tested for available soil N in the top 24 inches of soil. If only 0 to 12 inch depths were possible, values were multiplied by 1.5 to estimate the N level within a 0 to 24 inch depth. Dates of operations are listed in Table 2.

Table 1. Treatment List for Each Location		
Treatment #	Oat Variety	Soil + Fertilizer N (lb/ac)
1	CS Camden	Soil N only[1]
2	CS Camden	88
3	CS Camden	106
4	CS Camden	125
5	CDC Arborg	Soil N only[1]
6	CDC Arborg	88
7	CDC Arborg	106
8	CDC Arborg	125
[1]Background level of soil N (0-24") prior to seeding: Yorkton 24 lb N/ac; Prince Albert 39 lb N/ac; Outlook 20 lb N/ac; Melfort 57 lb N/ac		

Table 2. Dates of operations for each site conducted in 2023.				
Operation	Yorkton	Outlook	Melfort	Prince Albert
Pre-seed herbicide	None	Roundup Transorb HC @0.67L/ha on May 1	StartUp – May 19	Transorb – May 12
Seed Trial	May 17	May 11	May 16	May 31
Emergence	June 19	May 31	June 2	June 12
In-crop Herbicide	Prestige – June 5	Buctril M - June 8	Prestige XL – June 7	None
In-crop Fungicide	Trivapro – June 27	None	None	None
Yield kg/ha @13.5%	August 18	August 16	August 21	August 25
After harvest soil test for N (if possible 0-24). Composite for each treatment (4 in total)	August 27	August 17	September 1	September 11

8. Results:

Weather and yield potential

Tables 3 and 4 list the mean monthly temperatures and precipitation for the 2023 growing season along with long-term normals for each site in the study. The season was warmer and dryer than normal at all locations, resulting in lower-than-average yields at all locations excepting Outlook under irrigation. Oat yield was lowest at Prince Albert averaging 71 bu/ac. At Melfort and Yorkton oat yields were higher averaging 113 bu/ac and 120 bu/ac, respectively. At Outlook, yield was high, averaging 171 bu/ac under irrigation.

Table 3. Mean monthly temperatures amounts along with long-term (1981-2010) normals for the 2023 growing season at 4 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		----------*Mean Temperature (°C)* ----------				
Melfort	2023	14.1	19.2	16.9	17.3	16.9
	Long-term	***10.1***	***15.2***	***17.8***	***16.7***	***15.0***
Outlook	2023	15.2	19.5	18.5	18.7	18.0
	Long-term	***11.3***	***16.0***	***18.6***	***17.8***	***15.9***
Prince Albert	2023	14.4	18.8	16.6	17.1	16.7
	Long-term	***11.1***	***16.3***	***18.6***	***16.9***	***15.7***
Yorkton	2023	14.1	19.4	16.8	17.8	17.0
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***

Table 4. Precipitation amounts along with long-term (1981-2010) normals for the 2023 growing season at 4 sites in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		---------- *Precipitation (mm)* ----------				
Melfort	2023	31.5	26.4	16.4	50.0	124.3
	Long-term	***33.4***	***79.5***	***69.6***	***45.9***	***228.4***
Outlook	2023	17.2	15.3	15.5	16.6	64.9
	Long-term	***41.5***	***65.3***	***55.8***	***43.9***	***206.5***
Prince Albert	2023	22.8	52.8	40.8	51.2	167.6
	Long-term	***34.1***	***62.0***	***67.6***	***42.9***	***206.6***
Yorkton	2023	20	83.4	17.4	72.6	193.4
	Long-term	***51***	***80***	***78***	***62***	***272***

Table 5 lists the F-test results for main effects, site, and their interactions. Emergence differed significantly between sites with Outlook having the highest emergence rate (310 plants/m^2). Higher seeding rates are typically targeted under irrigation. Emergence at the remaining sites was similar varying from 241 to 261 plants/m^2. Significant effects of variety, fertility and site were detected for test weight and yield. A variety by site interaction was also detected for test weights. These significant effects will be discussed in greater detail where appropriate within this report.

Table 5. F-test Results for Variety, Fertility, Site and Their Interactions on Measured Parameters			
Factor	**Plant emergence**	**Test weight**	**Yield**
	Pr > F	Pr > F	Pr > F
Variety (V)	0.100	**<0.001**	**0.006**
Fertility (F)	0.629	**<0.001**	**<0.001**
Site (S)	**0.002**	**<0.001**	**<0.001**
V x F	0.886	0.413	0.781
V x S	0.086	**0.023**	0.114
F x S	0.829	0.402	0.351
V x F x S	0.447	0.146	0.343

Emergence

Plant emergence was adequate to maintain yield potential at all locations. Emergence was similar between CS Camden and CDC Arborg at all locations, except at Outlook, where CDC Arborg averaged 346.8 plant/m^2 compared to 274.0 plants/m^2 for CS Camden (Table 6). However, this difference likely had minor agronomic effects. As N rates were increased, plant stands were unaffected at all locations, indicating good separation between seed and N fertilizer. No interactions between variety and N fertility were detected.

Table 6. Main Effects and Individual Treatment Means for Emergence (plants/m^2) at each location.

Variety	Yorkton	Prince Albert	Outlook	Melfort	All sites
CS Camden	239.5	258.0	274.0[b]	259.4	253.7
CDC Arborg	243.6	253.8	346.8[a]	262.9	253.3
Lsd (Least Significant Difference)	Ns	Ns	46.0	Ns	Ns
Soil + Fertilizer N (lb/ac)					
Soil N[1]	236.2	260.0	300.0	262.9	254.8
88	247.7	255.5	325.5	254.3	253.2
106	257.5	259.5	291.3	267.8	261.1
125	224.7	248.5	324.8	259.6	244.8
Lsd	Ns	Ns	Ns	Ns	Ns
Linear	0.899	0.930	0.814	0.936	0.862
Quadratic	0.820	0.861	0.935	0.832	0.485
V x N					
CS Camden – Soil N[1]	218.2	252.0	265.0	254.3	244.1
CS Camden – 88 lb N/ac	252.6	256.0	283.0	252.7	254.3
CS Camden – 106 lb N/ac	262.5	262.0	295.5	258.4	269.6
CS Camden – 125 lb N/ac	224.8	262.0	252.5	272.3	252.9
CDC Arborg – Soil N[1]	254.2	268.0	335.0	271.5	282.2
CDC Arborg – 88 lb N/ac	242.8	255.0	368.0	255.9	280.4
CDC Arborg – 106 lb N/ac	252.6	257.0	287.0	277.2	268.5
CDC Arborg – 125 lb N/ac	224.7	235.0	397.0	246.9	274.9
Lsd	Ns	Ns	Ns	Ns	Ns
V x N interaction	Ns	Ns	Ns	Ns	Ns

[1]Background level of soil N (0-24") prior to seeding: Yorkton 24 lb N/ac; Prince Albert 39 lb N/ac; Outlook 20 lb N/ac; Melfort 57 lb N/ac

Test weight

Test weights were low at all locations except Outlook (Table 7). Oats with test weights above 245 g/0.5 l are accepted for milling at Grain Millers without discount. As test weights fall below 245 g/0.5 l, oats are progressively discounted for milling. Below 230 g/0.5 l, oats are rejected for milling. At Prince Albert, test weights were at rejection levels regardless of treatment. At Yorkton and Melfort, tests weights varied with treatment but stayed within the discount range. In contrast, test weights were well above discount levels at Outlook for all treatments. When sites were combined, the test weight for CDC Arborg was statistically higher than CS Camden. However, a site by variety interaction was detected (Table 5). When each site was analyzed individually, Outlook was the only site where CDC Arborg statistically had a higher test weight than CS Camden. While CDC Arborg numerically had the highest test weight at all locations, the difference was extremely small at Yorkton. Past work indicates CS Camden has a lower test weight than most oat varieties. However, this has not proven to be a concern for producers, as Grain Millers frequently accepts CS Camden for milling without discount (pers. Communication). When sites were analyzed together, increasing rate of N significantly decreased oat test weight linearly. Decreasing oat test weight in response to increasing soil N is a well-known phenomenon but the reason for its occurrence is not well understood. There were no variety by N rate interactions. However, assessing the impact of increasing N on each variety still has merit, as this shows the risk of rejection based on low test weight is greater for CS Camden compared to CDC Arborg.

Table 7. Main Effects and Individual Treatment Means for Oat Test Weight (g/0.5 l) at each location.

Variety	Yorkton	Prince Albert	Outlook	Melfort	All sites
CS Camden	234.6	201.6	251.1[b]	235.2	230.6[b]
CDC Arborg	235.0	212.5	254.7[a]	237.2	234.9[a]
Lsd	Ns	Ns	2.4	Ns	2.1
Soil + Fertilizer N (lb/ac)					
Soil N only	239.0	211.2	257.2[a]	239.0[a]	236.6[a]
88	234.5	209.9	251.4[b]	238.6[a]	233.6[ab]
106	233.5	205.2	253.2[b]	232.5[b]	231.1[bc]
125	232.3	201.9	249.8[b]	234.8[ab]	229.7[c]
Lsd	Ns	Ns	3.5	4.8	2.99
Linear	0.257	0.108	0.043	0.013	<0.001
Quadratic	0.122	0.232	0.034	0.072	0.477
V x N					
CS Camden – Soil N	240.5	206.6	256.3[a]	237.9	235.3[ab]
CS Camden – 88 lb N/ac	234.0	208.2	247.3[b]	238.7	232.0[bc]
CS Camden – 106 lb N/ac	232.0	199.8	250.6[b]	231.6	228.5[cd]
CS Camden – 125 lb N/ac	232.0	191.8	250.2[b]	232.7	226.7[d]
CDC Arborg – Soil N	237.5	215.9	258.1[a]	240.0	237.9[a]
CDC Arborg – 88 lb N/ac	235.0	211.5	255.5[a]	238.6	235.2[ab]
CDC Arborg – 106 lb N/ac	235.0	210.6	255.9[a]	233.3	233.7[ab]
CDC Arborg – 125 lb N/ac	232.5	212.1	249.4[b]	236.9	232.7[bc]
Lsd	Ns	Ns	4.9	Ns	4.23
V x N interaction	Ns	Ns	Ns	Ns	Ns

[1]Background level of soil N (0-24") prior to seeding: Yorkton 24 lb N/ac; Prince Albert 39 lb N/ac; Outlook 20 lb N/ac; Melfort 57 lb N/ac

Yield

Averaged across fertility, CDC Arborg was higher yielding than CS Camden at all sites. Differences in yield were less than 2% and were not statistically significant at Yorkton and Prince Albert (Table 8). Yield differences of 4% and 16% were statistically different at Outlook and Melfort, respectively. CDC Arborg also proved to be statistically higher yielding than CS Camden when all sites were analysed together. Yields increased with increasing N fertility at all locations. Even though a nitrogen by site interaction was not detected, N response results for Outlook have been separated from the other sites to create figures 1 and 2. This was done as the yield response to added N was greatest at Outlook and amount of residual soil N left over after harvest was much less at this location. Since there were no V x N interactions at any site, the yield response of Oats to added N has been averaged over variety within these figures.

Yields were relatively low and unresponsive to added N due to drought at Prince Albert (71 bu/ac), Yorkton (121 bu/ac) and Melfort (113 bu/ac). As the rate of spring applied N was increased at these locations, the amount of post-harvest soil nitrate-N also increased, since much of the applied N was not going to yield because of the drought (Figure 1). Applying 85 lb N/ac in spring increased the level of soil N post-harvest by 25 lb N/ac. It is difficult to make many conclusions from this information. We know 25 lb/ac of the 85 lb/ac was left-over in the soil as nitrate but we don't know much about where the remaining 60 lb/ac went. A good portion likely went to increasing Oat yield and grain protein. A small portion may still be in the ammonium form which is not detected by a conventional soil test. Other losses to the system include volatilization, denitrification, leaching and immobilization. Determining how much of the applied N was used by the crop based on post-harvest residual N cannot be made accurately.

In contrast, oat yield was much higher and more responsive to added N under irrigation at Outlook (Figure 2). Moreover, soil nitrate after harvest was not increasing with increasing rate of spring applied N. In fact, it was low and declining. While more of the applied N was going towards yield under irrigation, more of it was likely lost to denitrification and leaching.

Table 8. Main Effects and Individual Treatment Means for Oat Yield (kg/ha) at each location.

Variety	Yorkton	Prince Albert	Outlook	Melfort	All sites
CS Camden	4562.5	2695.8	6390.7[b]	3993.3[b]	4410.6[b]
CDC Arborg	4648.8	2730.2	6665.9[a]	4641.7[a]	4671.7[a]
Lsd	Ns	Ns	116.9	311.8	199.1
Soil + Fertilizer N (lb/ac)					
Soil N only	4037.8	2526.1	4780.6[c]	3919.1[b]	3815.9[b]
88	4882.8	2808.5	6913.8[b]	4133.2[b]	4684.6[a]
106	4921.5	2716.5	7185.6[a]	4616.1[a]	4859.9[a]
125	4580.5	2801.0	7233.3[a]	4601.7[a]	4804.1[a]
Lsd	Ns	Ns	165.3	441.0	281.6
Linear	0.073	0.150	<0.001	0.017	<0.001
Quadratic	0.046	0.289	<0.001	0.055	<0.001
V x N					
CS Camden – Soil N	3927.0	2404.9	4689.0[d]	3567.3[d]	3647.0[c]
CS Camden – 88 lb N/ac	4670.0	2738.9	6797.0[c]	3918.8[cd]	4531.2[b]
CS Camden – 106 lb N/ac	4697.0	2759.4	6993.9[bc]	4306.0[bc]	4689.1[ab]
CS Camden – 125 lb N/ac	4956.0	2880.1	7082.8[b]	4181.3[cd]	4775.0[ab]
CDC Arborg – Soil N	4148.5	2647.3	4872.2[d]	4271.0[c]	3984.7[c]
CDC Arborg – 88 lb N/ac	5095.5	2878.1	7030.6[bc]	4347.6[bc]	4837.9[ab]
CDC Arborg – 106 lb N/ac	5146.0	2673.6	7377.3[a]	4926.2[ab]	5030.7[a]
CDC Arborg – 125 lb N/ac	4205.0	2722.0	7383.7[a]	5022.2[a]	4833.2[ab]
Lsd	Ns	Ns	233.8	623.0	398.3
V x N interaction	Ns	Ns	Ns	Ns	Ns

[1]Background level of soil N (0-24") prior to seeding: Yorkton 24 lb N/ac; Prince Albert 39 lb N/ac; Outlook 20 lb N/ac; Melfort 57 lb N/ac

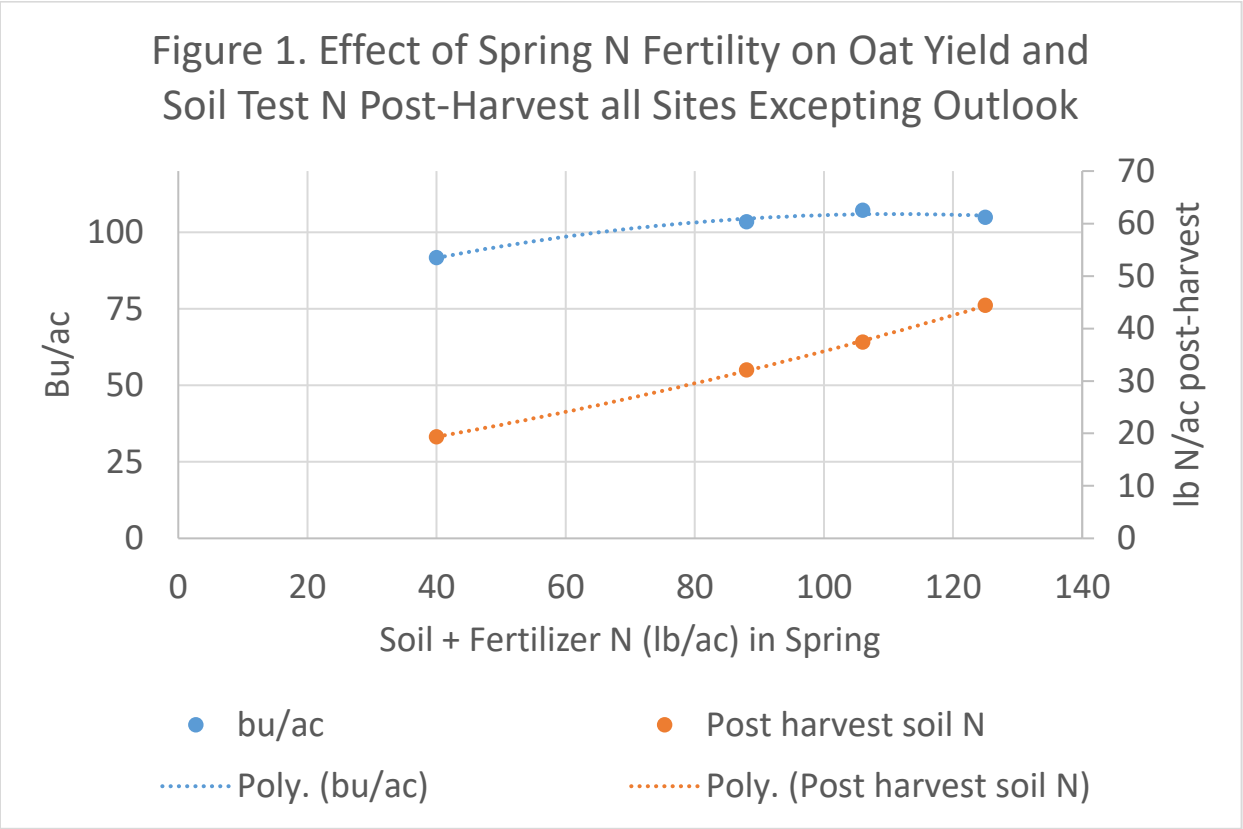
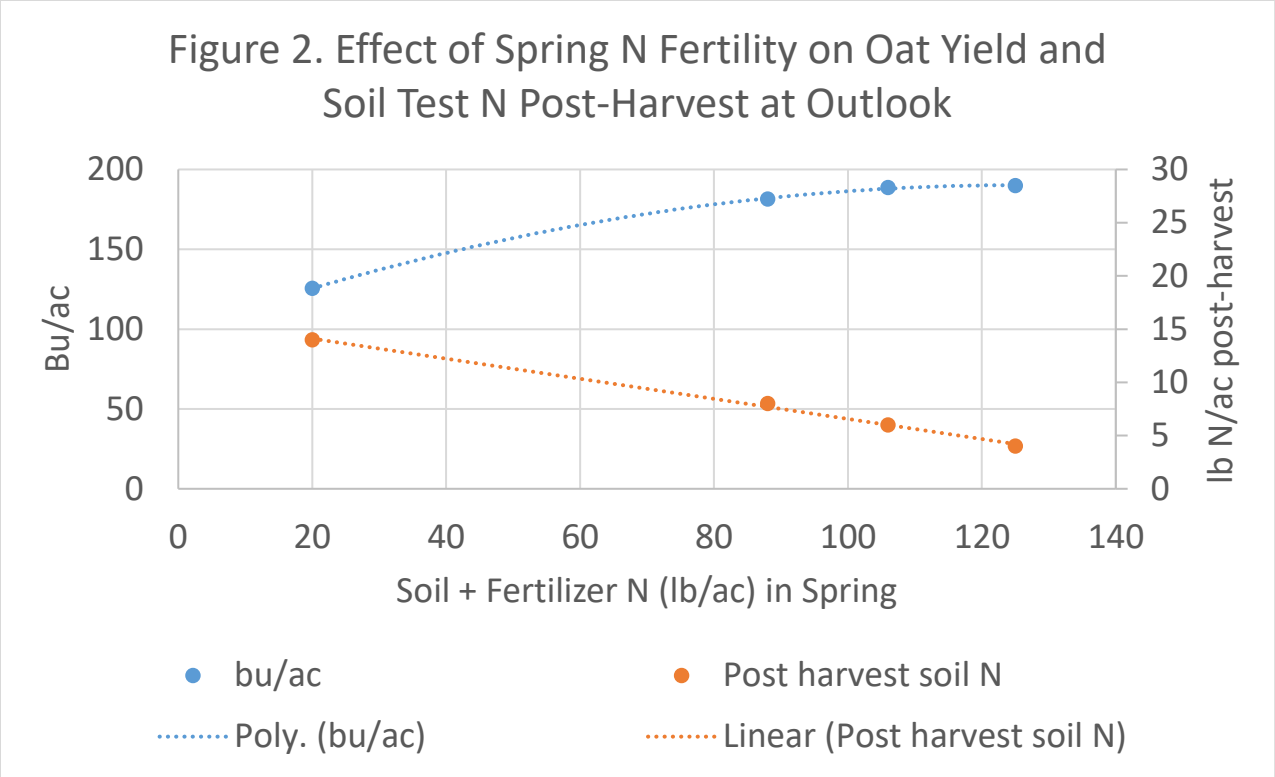


Figure 1. Effect of Spring N Fertility on Oat Yield and Soil Test N Post-Harvest all Sites Excepting Outlook
Bu/ac
100
75
50
25
0
70
60
50
40
30
20
10
0
lb N/ac post-harvest
0
20
40
60
80
100
120
140
Soil + Fertilizer N (lb/ac) in Spring
bu/ac
Post harvest soil N
Poly. (bu/ac)
Poly. (Post harvest soil N)



Economics

The objective of this study was to determine the impact of reducing levels of recommended N for oats by 15% and 30% on yield and economic returns. To make this determination, Table 9 lists the economic impact for each incremental decrease in N for Outlook and for all locations combined excepting Outlook. Prices of $0.82/ lb N and $5.25/ bu of oats were used to determine net returns and these values were obtained from the 2024 Saskatchewan Crop Planning Guide. Table 9 shows net revenue generated based directly on data point yields vs values calculated from the response curves. While there are pros and cons to each of these approaches general conclusions were very similar between the approaches.

Decreasing the fertility rate by 15% from 125 to 106 lb N/ac increased net revenue for the high yielding Outlook site and the combined lower yielding sites. In other words, increasing N fertility beyond 106 lb N/ac was costing money at all locations. Reducing the N fertility level by another 15% (106 to 88 lb N/ac) reduced net returns at Outlook and either modestly increased or decreased net returns for the low yielding sites depending on whether data points or response curve values were used in the calculation. Said another way, reducing the N fertility from 125 lb/ac by 15% was saving money at Outlook but a further reduction by 15% was reducing net returns by approximately $20/ac. In contrast, reducing N fertility by 30% was the most economical for the low yielding sites.

Table 9. Effect of Incremental decreases in N fertility on Net Revenue[1].		
	Net Revenue ($/ac) Generated Based on Data Points	
N Fertility Decrease	Outlook	All sites Excepting Outlook
125 lb N/ac to 106 lb N/ac	9.00	28.02
106 lb N/ac to 88 lb N/ac	-22.70	-4.97
	Net Revenue ($/ac) Generated Based on Response Curve	
N Fertility Decrease	Outlook	All sites Excepting Outlook
125 lb N/ac to 106 lb N/ac	3.86	17.16
106 lb N/ac to 88 lb N/ac	-16.61	6.47
[1]Net Revenue based on 0.82/lb N and $5.25/bu oat. Values taken from 2024 Saskatchewan Crop Planning Guide.		

9. Conclusions and Recommendations

In conclusion, reducing 125 lb N/ac of soil + fertilizer N by 15% was economical at all sites under the conditions of this study. Decreasing total N by 30% to 88 lb/ac of soil + fertilizer N was still economical for the combined low yielding sites but reduced net returns by about $20/ac at the high yielding Outlook site.

For the combined low yielding sites, increasing the level of spring N fertility at seeding lead to higher levels of soil test N after harvest. On average, increasing soil N from 40 to 125 lb/ac increased background soil N post-harvest from 19.3 to 44.4 lb N/ac. While at least 25 lb/ac of the 85 lb/ac of applied N were clearly not used by the crop, it is still difficult to speculate on how much N was used by the crop due to multiple mechanisms of N loss. For the high yielding Outlook site, background levels of soil N post-harvest were very low and did not increase with increasing rate of spring applied N. While much of the applied N was likely used by the high yielding crop, soil reserves of N may have also been lost to denitrification and leaching.

Supporting Information

10. Acknowledgements: SaskOat

Abstract

Abstract/Summary:

In 2023, trials were established at Yorkton, Melfort, Outlook, and Prince Albert to determine the impact of reducing levels of recommended N for oats by 15% and 30% on yield and economic returns. The study was conducted during widespread drought, which reduced the responsiveness of yield to added N at all locations except Outlook under irrigation. Reducing the soil + fertilizer N from 125 lb/ac to 106 lb/ac (15% reduction) resulted in an economic gain at all locations, including Outlook where yields were high and responsive to added N. Reducing soil + fertilizer N further from 106 lb/ac to 88 lb/ac resulted in economic losses at Outlook of approximately $16-22/ac depending on whether actual data point values or response curve values were used to make the determination. For the combination of the low-yielding sites, reducing N fertility to 88 lb/ac (30% reduction) was either modestly economical or uneconomic depending on the method to make the determination. Essentially, yield was not highly responsive to added N beyond 88 lb/ac. If environmental conditions had been ideal in this study, higher rates of N would have proved more economical. For the dry land sites, post-harvest levels of soil test N increased as added N in spring was increased. On average, soil tests found 25 lb N/ac of the 85 lb N/ac of applied fertilizer to dry land sites was still in the ground post-harvest. However, it is difficult to estimate how much of the applied N was used by the crop due to multiple means of loss. For the high yielding irrigation site at Outlook, post-harvest levels of soil test N were low for all treatments. While more of the applied N would have gone to yield under irrigation, it is also possible that more of the soil N was also lost to leaching and denitrification.