PROGRESS REPORT

PROJECT TITLE: Is Fixed Ammonium an Important Part of Nitrogen Cycling?
PROJECT NUMBER: 6133-24DD (U of M CON000000109321)
REPORTING PERIOD: Jan. 1 – Mar. 31, 2025
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1.) PROJECT ACTIVITIES COMPLETED DURING THE REPORTING PERIOD. (*Describe project progress specific to goals, objectives, and deliverables identified in the project workplan.*)

We have been busy completing work on all the soil samples collected in 2024. Currently we are done, other than a few re-runs, on all soil and plant samples through 2023. I asked for an extension to the current grant to give more time to complete the 2024 soil samples. Below is a list of what remains from 2024

- Grain samples have been submitted for analysis, but I do not have the data back
- Soil fixed ammonium analysis needs to be determined on the fall post-harvest soils.
- Extractable soil test potassium analysis needs to be completed on 3 of the 4 locations
- Extractable soil ammonium and nitrate need to be determined on all fall soil samples
- 7-day tetraphenylboron K determinations need to be completed on all 2024 soils

I have included a brief summary of some of the key results thus far below. Most, if not all, the remaining work should be completed by June.

2.) IDENTIFY ANY SIGNIFICANT FINDINGS AND RESULTS OF THE PROJECT TO DATE.

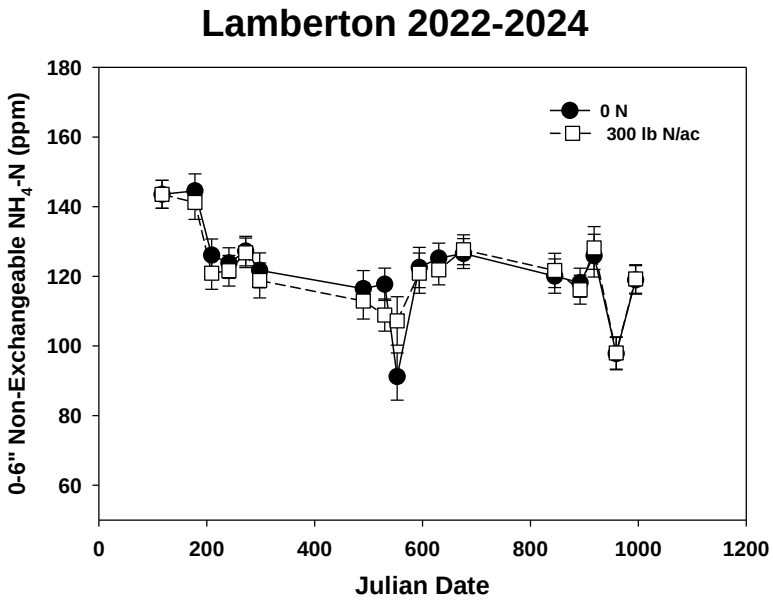

Figure 1. Total of non-exchangeable ammonium extracted from 0-6” soil samples Collected monthly at Lamberton, MN from 2022 to 2024 for 0 versus 300 lb N application rates averaged across all the K application rates. Asterisks denote specific dates where there was a significant difference between the two N rates.

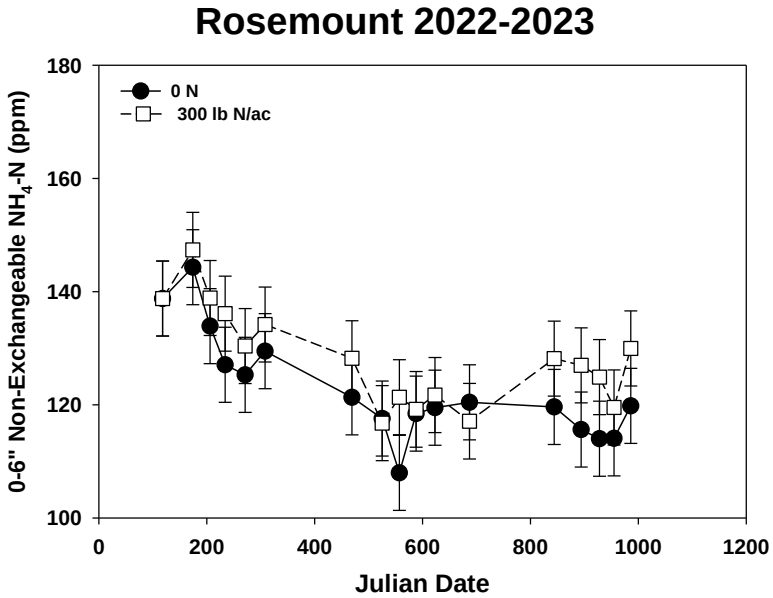

Figure 2. Total of non-exchangeable ammonium extracted from 0-6” soil samples Collected monthly at Rosemount, MN from 2022 to 2024 for 0 versus 300 lb N application rates averaged across all the K application rates. Asterisks denote specific dates where there was a significant difference between the two N rates.

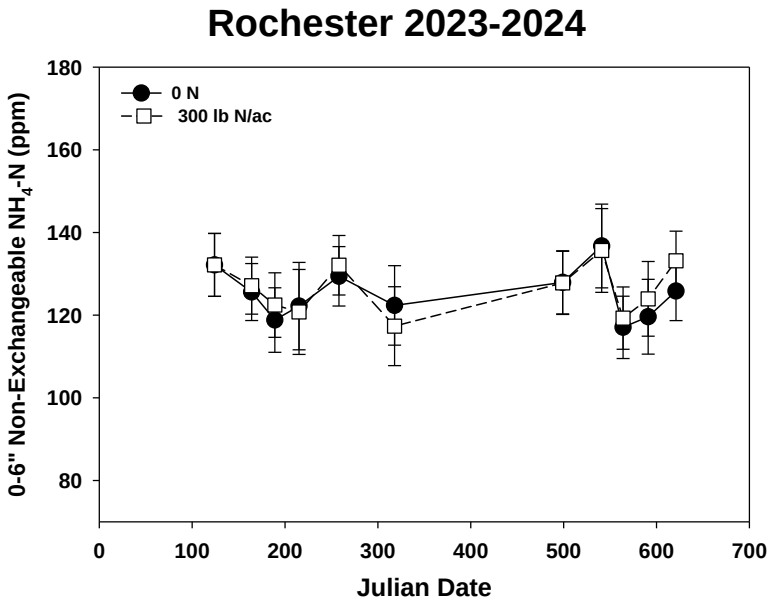

Figure 3. Total of non-exchangeable extracted from 0-6” soil samples Collected monthly at Rochester, MN from 2023 to 2024 for 0 versus 300 lb N application rates averaged across all the K application rates. Asterisks denote specific dates where there was a significant difference between the two N rates.

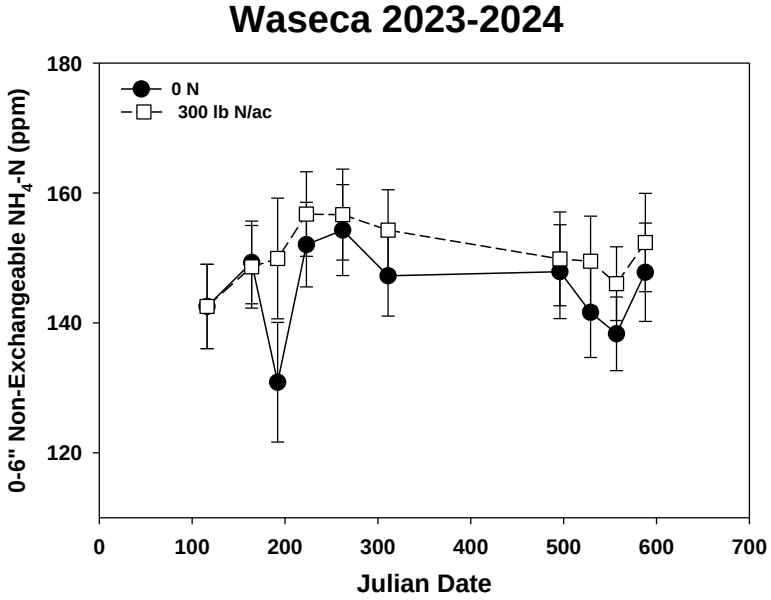

Figure 4. Total of non-exchangeable extracted from 0-6” soil samples Collected monthly at Rochester, MN from 2023 to 2024 for 0 versus 300 lb N application rates averaged across all the K application rate. Asterisks denote specific dates where there was a significant difference between the two N rate.

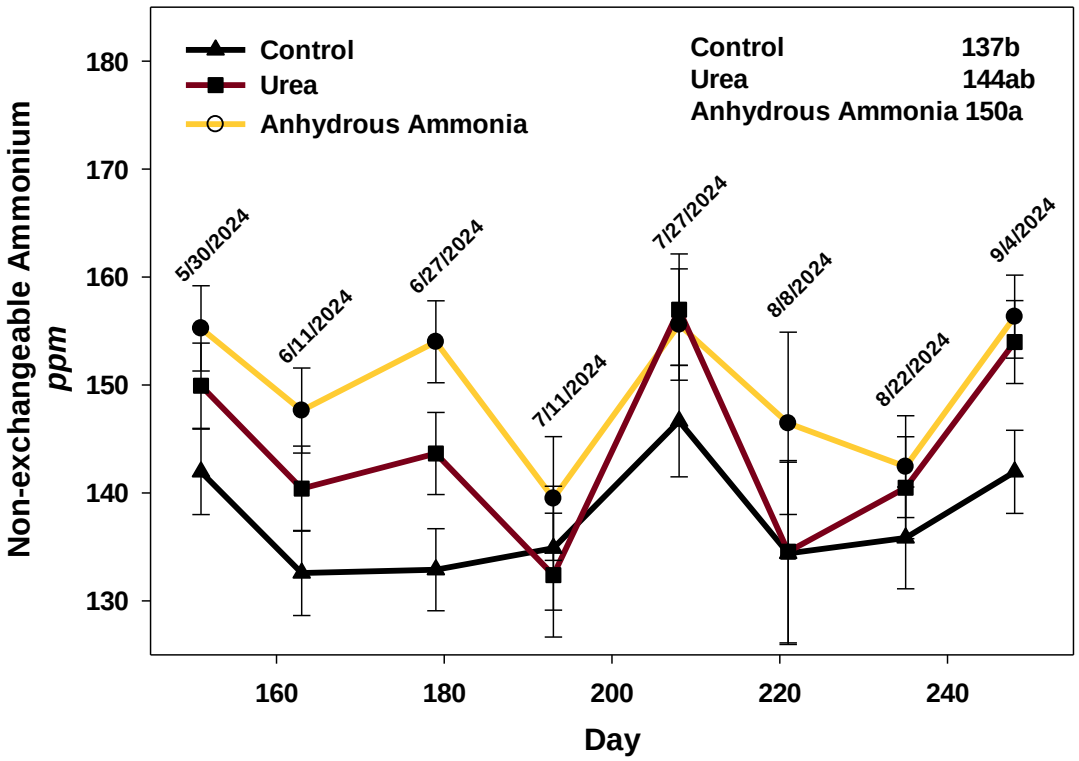

Figure 5. Non-exchangeable extracted from 0-12" soil samples Collected monthly at Waseca, MN in 2024 for comparing a control (no N) versus 280 lbs of spring applied N as urea and anhydrous ammonia. Asterisks denote specific dates where there was a significant difference between the two N rate.

Included in Figures 1 through 5 is the summary data to date for the fixed ammonium results averaged across all the K rates for the two N rates. This data was presented at the 2024 ACS meetings in San Antonio, TX in November. We have not found a major difference between the 0 and 300 lb N rates in fixed ammonium across all the sites. The major difference we have found has been changes in fixed ammonium over time. At Lamberton and Rosemount there has been a sizeable drop in the amount of fixed ammonium extracted over time. Concentrations were greater at the start of the trial then decreased and remained lower in both continuous corn years. The data for Rosemount and Waseca do not show the same results; however, we only have the first full year of data analyzed from those two locations. What I would like to know if the drop in fixed ammonium would be consistent with the increase in optimal N rate over time at the two locations. The data also has me wondering whether some of the N that we consider to be part of the nitrogen credit supplied by soybeans could be previously fixed ammonium during the soybean year being utilized by corn.

The data from Waseca in Figure 5 does indicate that anhydrous ammonium may increase fixed ammonium more than urea. Overall, the sampling times the fixed ammonium concentration were greater than the control only for anhydrous ammonium. Concentrations following urea application were no different from AA but also no different from the non-fertilized control. Since we used urea for the field trials, we may not be able to detect differences between the 0 and 280 lb rate and we possibly could have found differences if AA was used. One of the objectives was to compare sources of N and I think we can say definitively there is likely some differences in sources in how they might add to the concentration of fixed ammonium in the soil.

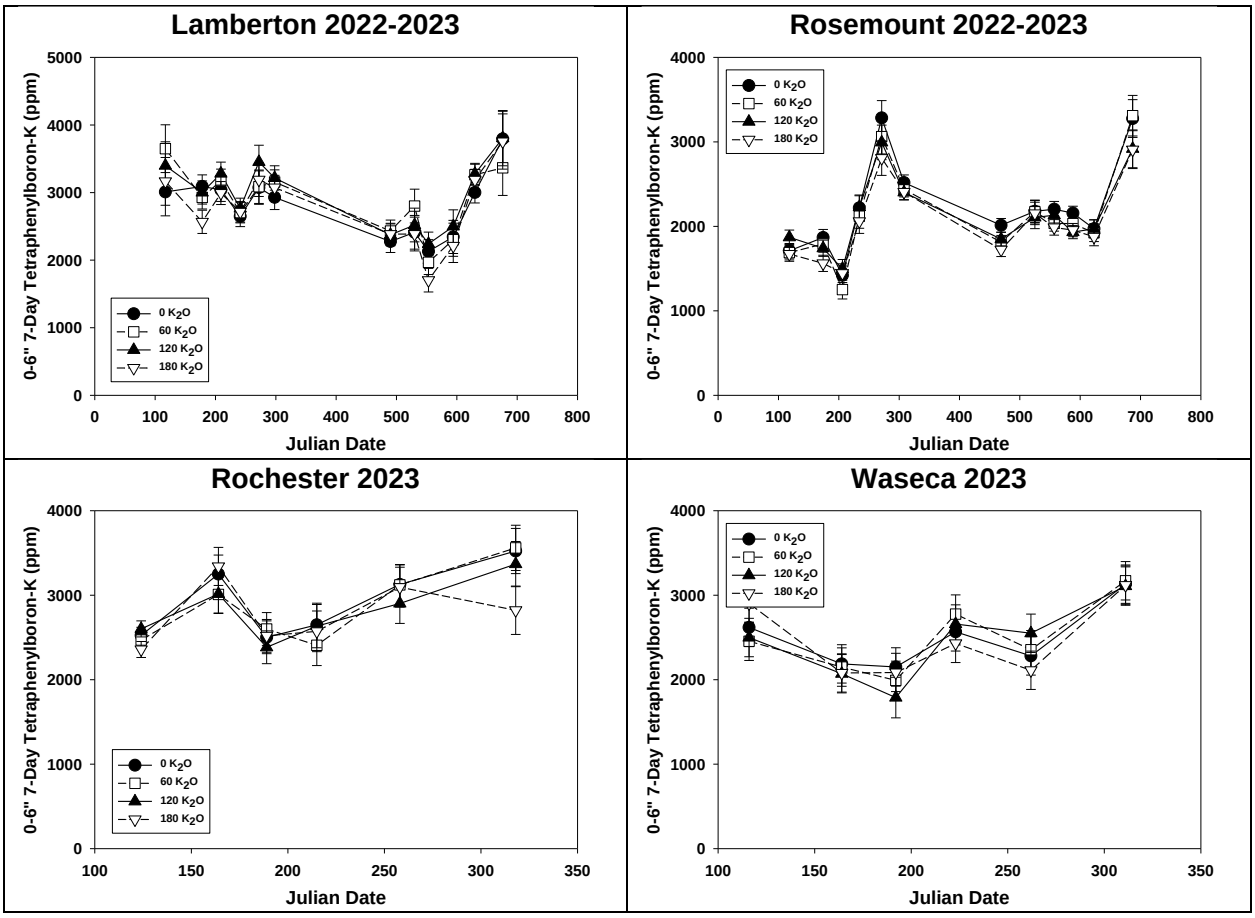

Figure 6. Summary of soil K extracted by 7-day incubation with sodium tetraphenylboron by K application rates for all sites through the end of the 2023 growing season.

Results for the K-tetraphenylboron data are given in Figure 6 for the 7-day incubation period. We have also run the 5-minute incubation on the same samples which were covered through AFREC. I am not including the 5-minute incubation data as I have not had much time to go through the data yet. For the 7-day incubation I did not expect much change over time, nor did I expect a change in the TBK values based on the K application rates in the near term. There have been larger fluctuations in the data over time than I had expected, and I am not sure the exact reason for these fluctuations. For example, Rosemount the KTB values tended to be greater near the Fall sampling both years. I have rerun the data on these samples and the results have been similar. If we are measuring all the non-exchangeable K the values should not change that much. I can only theorize that it is possible that the soil at Rosemount that has more mica that potentially is not getting all the K extracted from the non-exchangeable fraction possibly due to the K layers collapsing. That should not happen, but I have not found much information on the TBK values over a monthly sampling window. I do have soil moisture data on all the samples so it will be important to investigate these changes in relation to soil moisture. I have also not related the data too closely to the fixed ammonium data. Initial correlations did not show much, if any, correlation between fixed ammonium or potassium. I had theorized that potentially each may replace the other if one value increases or decreases but I am not sure at this point looking at how the fixed ammonium has changed over time relative to potassium.

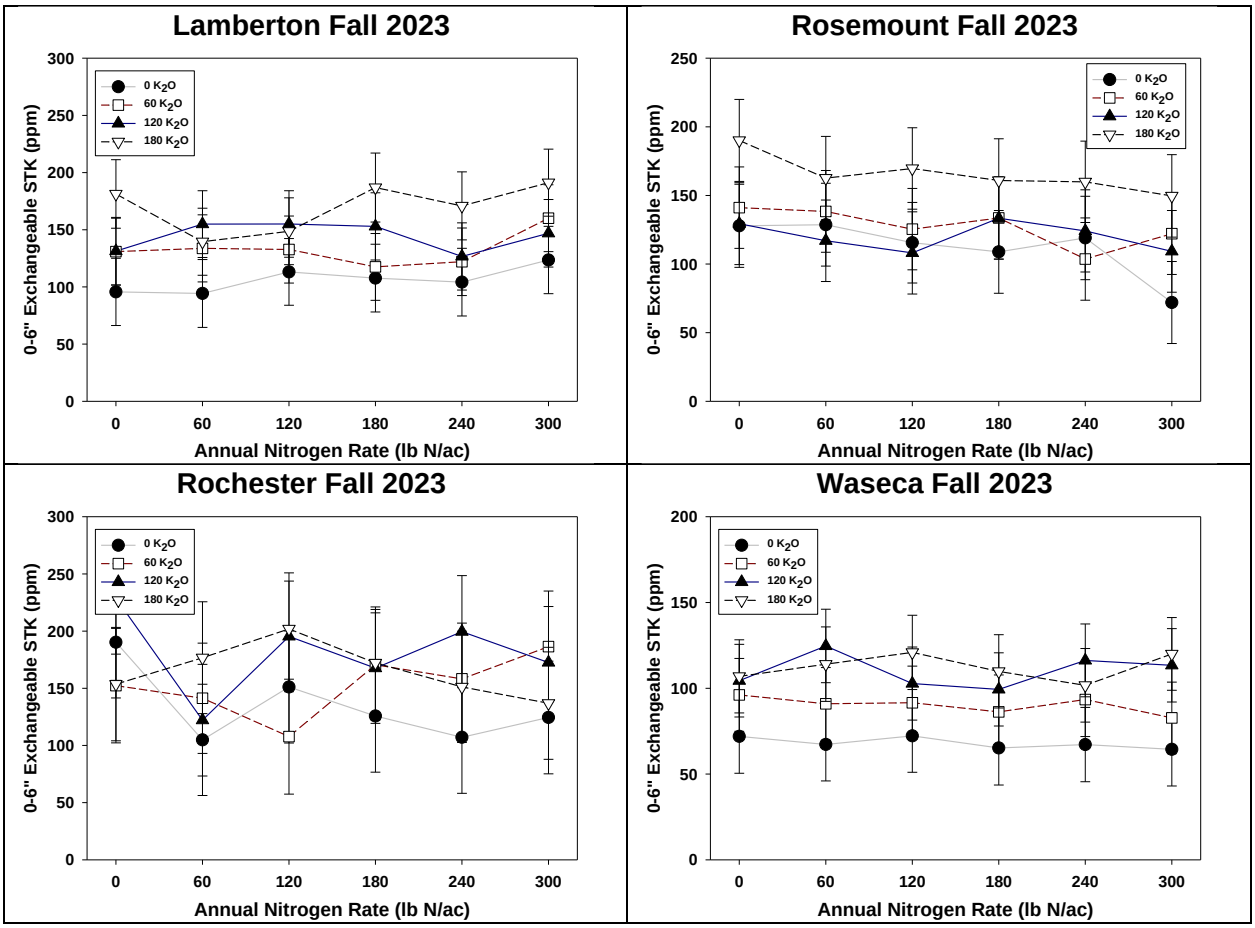

Figure 7. Summary of soil test K extracted on field moist samples collected in the fall post-harvest in 2023 summarized for each K application treatment across the 6 rates of N applied.

Extractable soil test K data are summarized in Figure 7 for the 2023 post-harvest samples. Analysis of 2024 samples is in progress currently. However, the 2023 data show some interesting results particularly in how soil test K is responding to N application rate at 3 of the 4 locations. The application of K in general has resulted in an increase in STK across locations. However, there were significant interactions between N and K at three locations. At Lamberton there has been a slight increase in STK with an increasing N rate. However, STK tended to decrease with an increasing rate at Rochester and Rosemount. The decrease in STK follows the fact that the increased yield due to N would result in greater uptake and removal of K. Therefore, the greater K demand would put greater pressure on the soil test K over time. I am not sure what the results are opposite at Lamberton. However, the 2024 data which I am not showing from Lamberton shows a similar decrease in STK with increasing N rate. Since the 2024 data at Lamberton reflects the greater removal of K over three years I would expect to see a greater difference in STK after year three. I have also been measuring the 6-12 and 12-24” soil test K values but there was no effect of K or N fertilizer on deeper soil test K at most of the locations.

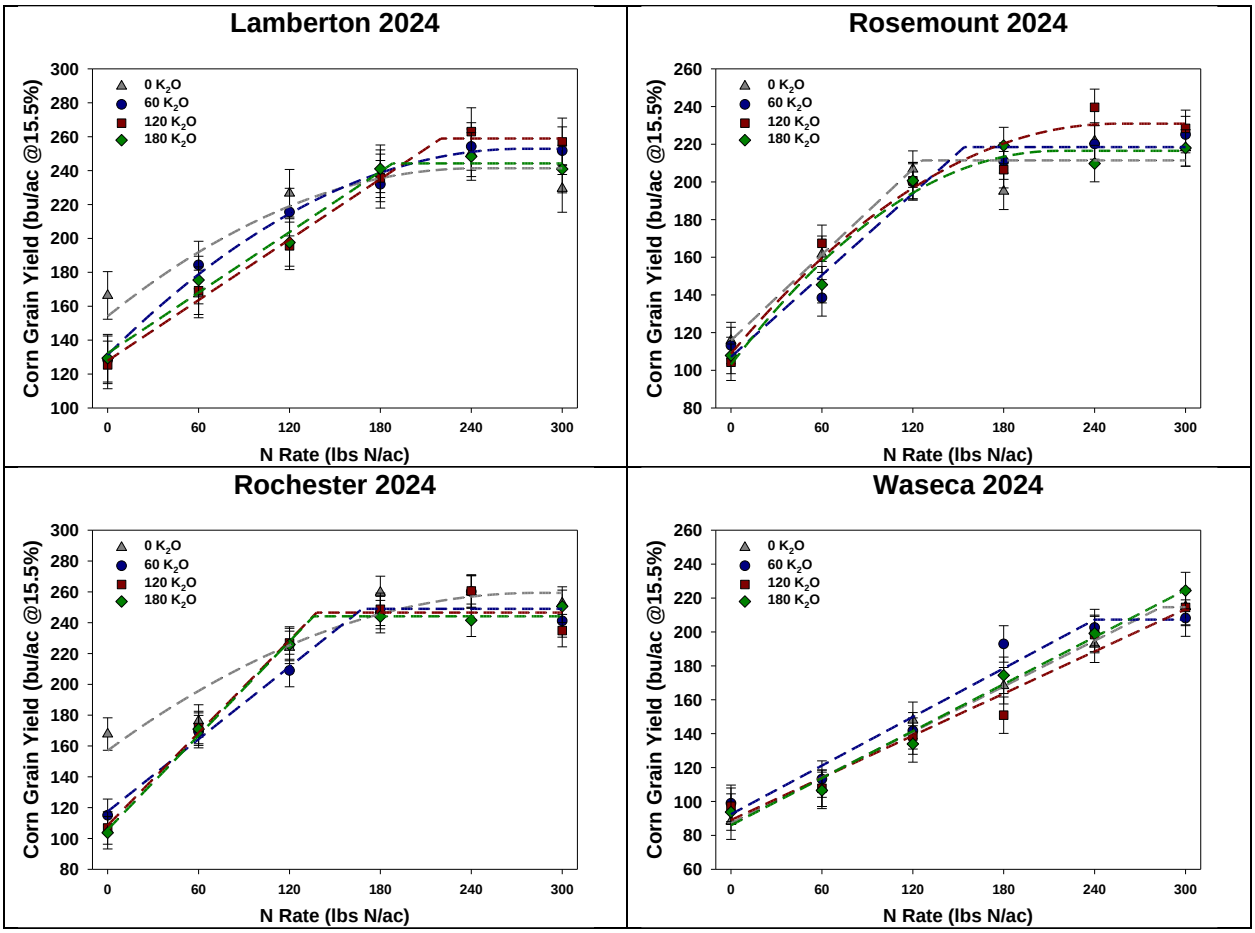

Figure 8. Summary corn grain yield response to N by the rate of K2O applied for the 2024 growing season.

Corn grain yield data for 2024 is summarized in Figures 8 and 9. Figure 8 summarizes response to N by K application rate. However, there was no evidence of a response to K nor any interaction between K and N at any of the locations. Therefore, a simplified yield curve for each site showing the response to N across all K rates are given in Figure 9. All sites in 2024 were corn following corn with Lamberton and Rosemount being the second year of corn following corn. We found relatively high responses to N across all the locations with many showing an increase in corn grain yield up to or close to the highest rate of N applied. I am in the process of putting the 2024 nitrogen response data into the corn N rate calculator to update the N guidelines. When I added the 2023 data it changed slightly. I will be working on adding the 2024 data soon.

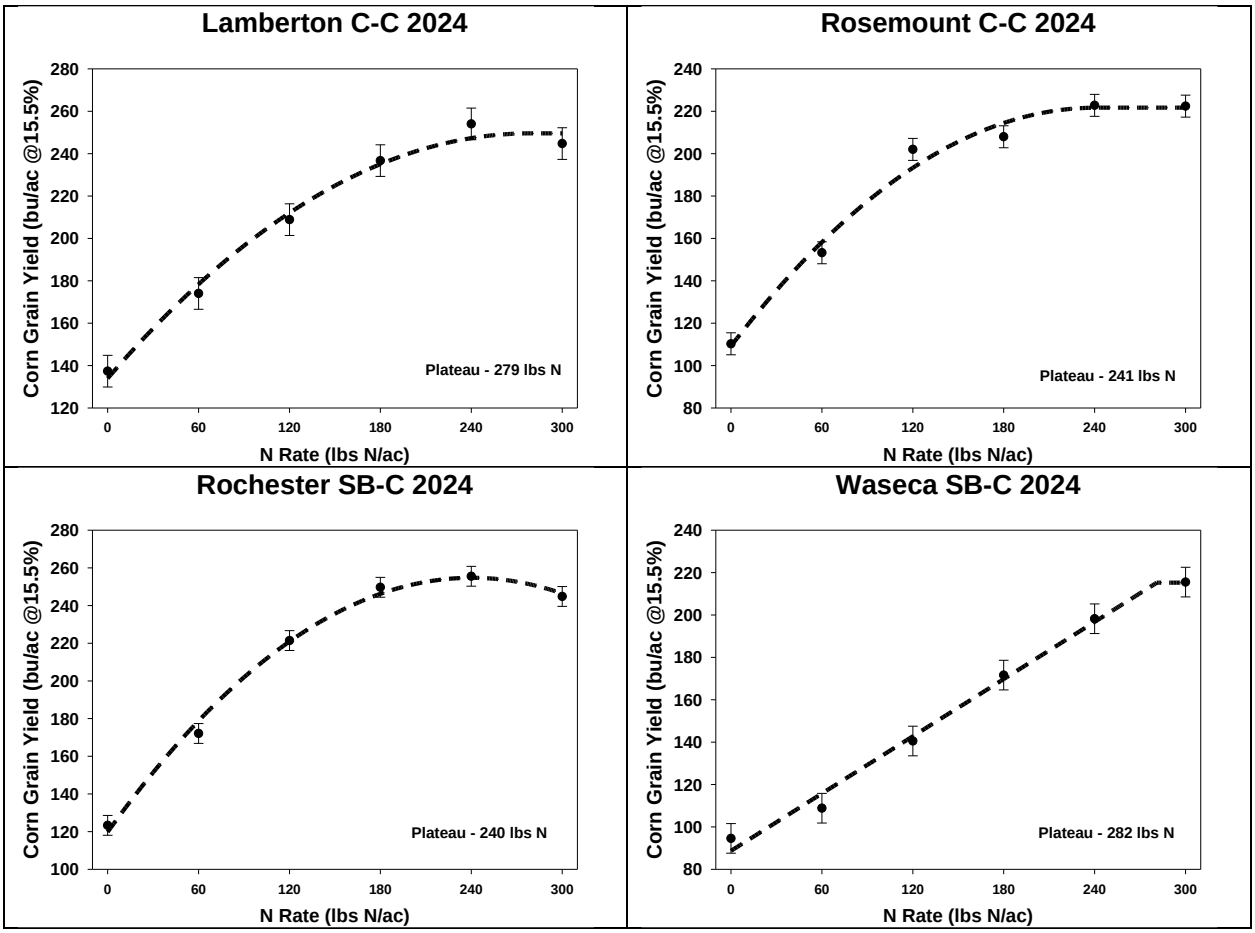

Figure 9. Summary corn grain yield response to N across the four K rates for the 2024 growing season.

3.) CHALLENGES ENCOUNTERED. (*Describe any challenges that you encountered related to project progress specific to goals, objectives, and deliverables identified in the project workplan.*)

None

4.) FINANCIAL INFORMATION (*Describe any budget challenges and provide specific reasons for deviations from the projected project spending*.)

None

5.) EDUCATION AND OUTREACH ACTIVITES. *(Describe any conferences, workshops, field days, etc attended, number of contacts at each event, and/or publications developed to disseminate project results.)*

None in Q4 of 2024