

## **Calibration of Nitrogen Requirement of Oats Grown for Grain in South Dakota**

**PI and Collaborators:** David Karki (PI), Anthony Bly, Sara Bauder, and Peter Sexton

**Report: 1-1-2018 to 12-31-2018.**

### **Project Summary**

The fertilizer recommendations guide for crop grown in South Dakota (SD) was last updated in 2005 (EC750, 2005), and the nitrogen (N) recommendation for the oat grain crop are generally higher than the guidelines recommended by other public institutions. The SD guideline uses expected yield goal (YG) to be multiplied by 1.3 (minus soil test N and legume credit) to estimate total N requirement for oats grown for grain. Perhaps, due to improved genetics and other management tools, producers in productive environments have consistently grown oat crop with yield of more than 100 bu/a with significantly lower levels of nitrogen than recommended in the EC750 guide. This study aims at developing an up-to-date nitrogen fertilizer recommendation for oat grain crop production in SD. This will help narrow the knowledge gap among oat growers in terms of applying the correct amount of nitrogen fertilizer on oat crops consequently maximizing production and profitability. Further avoiding over applying nitrogen will not only help growers reduce harvest loss by excessive lodging but also minimize the negative impact on environment. The study was proposed in early summer 2017 and was selected for the award in August 2017.

### **Objectives**

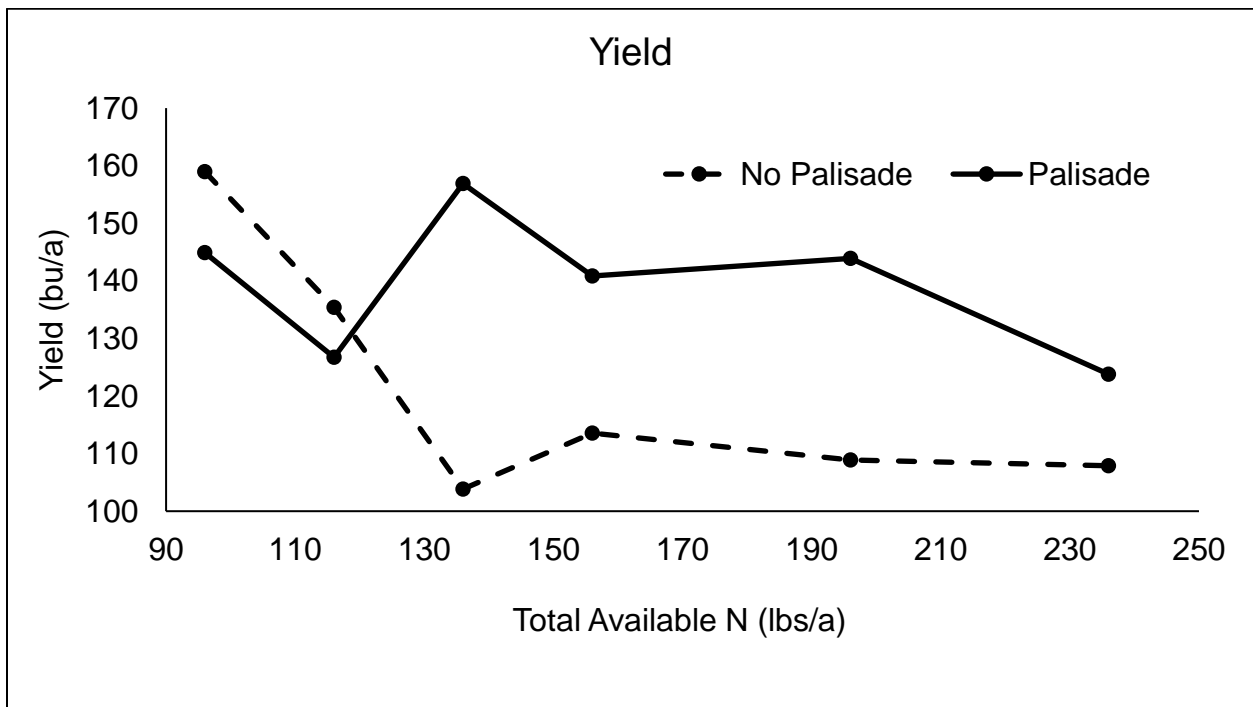
The goal of the proposed study is to develop a revised nitrogen fertilizer recommendation for oat grown for grain production in SD environments. The objective of this study is to determine oat yield response to varying levels of applied nitrogen fertilizer. Some SD growers have shown interest in using growth regulators to shorten plant height as a mean to prevent lodging. In one or more location, we plant to use both growth regulator and nitrogen levels as possible treatments. This will allow us to see if there is any financial benefit of using growth regulator to increase grain yield by applying higher N rates without potential crop lodging.

### **Results**

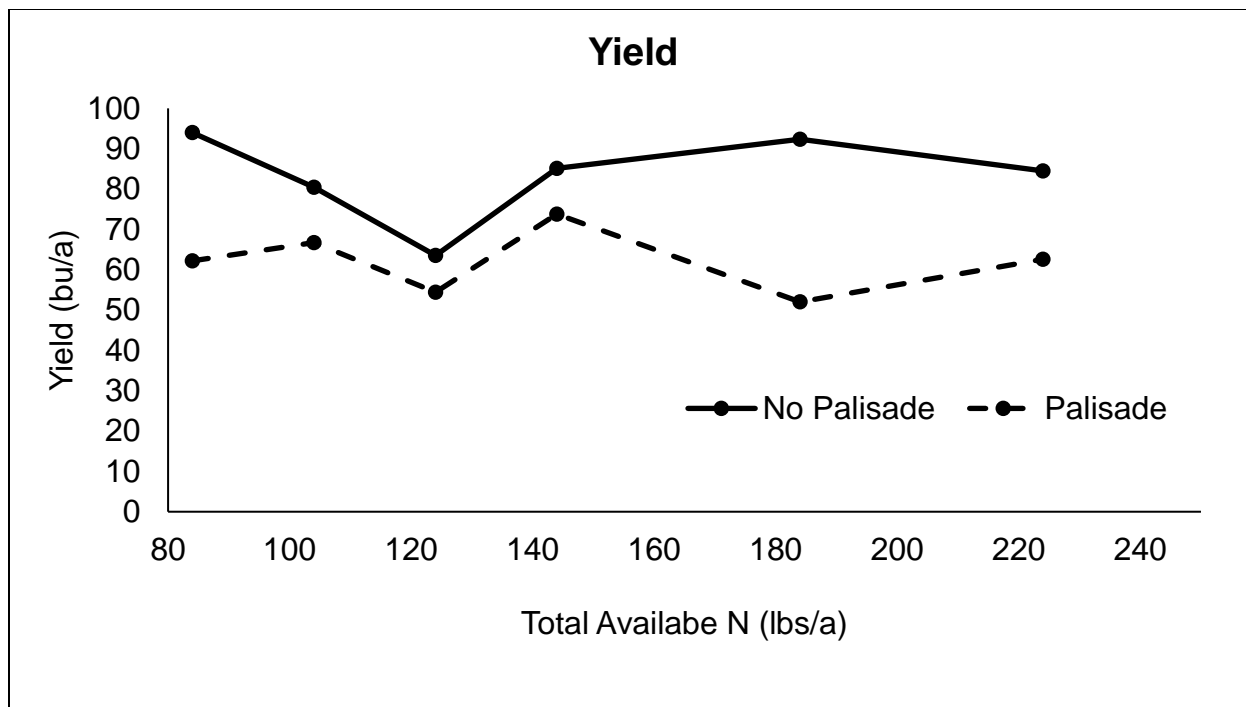
Five eastern SD sites- two farmer cooperators field in Brookings and McCook County, and three SDSU Research Stations- Aurora Farm, NE Research Farm, and SE Research Farm were utilized to conduct the trial in 2018 growing season. We applied 20, 40, 60, 100, and 140 lbs/a rates of nitrogen at or pre-planting at all sites except at Brookings site, where the cooperator had to plant oats on field different than initially planned due to prolonged spring moisture on the field. The new field was already fertilized (with urea) when we were made aware. Therefore, we decided not to use the highest rate (i.e. 140 lbs/a) in Brookings site. At NE and SE Farms,

Due to the timing of the received award, we were able to initiate the proposed three-year study in 2018 growing season. At this point we do not have any results to present, however, this section clearly defines the methods followed this year. A 'control' plot which did not receive any additional N was added in the experimental block at all sites. At SDSU NE and SE Research Farms, each nitrogen treatment was split for additional treatment with plant growth regulator (PGR) and the effects of PGR were evaluated under different nitrogen regimes. Fields at all locations were planted with variety 'Hayden' except Brookings which was planted with variety 'Goliath'. (Note: Variety decision was made by the producer). Before applying N treatments, a composite soil sample from 0-6" and 6-24" were collected to test for pre-trial N level. The N treatments were arranged in Randomized Complete Block (RCB) design with three replicates at all sites. The plot size was 15' x 30'. The PGR Palisade EC (Syngenta) was applied at Feekes growth stage 5-6 (leaf sheath strongly erected-first node visible).

**NE Farm by South Shore and SE Farm by Beresford**



**Fig 1. Average Oat Yields under Various Nitrogen levels and Plant Growth Regulator 'Palisade' at NE Research Farm.**



**Fig 2. Average Oat Yields under Various Nitrogen levels and Plant Growth Regulator ‘Palisade’ at SE Research Farm.**

The PGR used in this study was able to significantly reduce height and lodging on oats. At NE farm, the highest yield of 159 bu/a was achieved without applying any extra N which suggest that, the total available N in the soil (96 lbs/a) was enough to produce optimal yield under 2018 growing conditions. At NE farm, the highest yield to applied N ratio for non-PGR plots was 0.6. On the other hand, highest yield to N ratio for PGR applied plots was 0.85 (Fig 1.)

Similar to NE farm, the pre-trial N of 84 lbs/a at SE farm was enough for achieving the highest grain yield in this trial. The trend of grain yield response for applied N treatments and PGR were almost identical except for 180 lbs/a N plots (Fig 2.). The yields were significantly lower than NE farm which could be due to elevated stress in early growth stage caused by delayed planting and extremely high temperatures in May. The highest yield of 94 bu/a was achieved for ‘control’ (no additional N) treatment, which shows that even under low production weather conditions, 0.9 lbs N was able to produce a bushel of oat grain.

### **Aurora Research Station, Salem, and Bruce**

At these three locations, PGR was not used, therefore, height notes were not obtained as there were no visible differences in height. Plots at Aurora were 100% for all applied treatments due to two due extremely strong storm in quick succession in late July. The highest yield of 93 bu/a was obtained for control plots which had 88 lbs/a of pre-trial N.

At Bruce, the yields were comparatively higher than other locations which ranged from 155 bu for 100 lbs/a N treatment to 161 bu/a for control. The pre-trial N in Bruce was 92 lbs/a. The lodging score ranged from 30% (control) to 47% (100 lbs N/a).

At Salem, the yields ranged from 112 bu/a (control) to 143 bu/a (60 lbs N/a). The pre-trial N at this location was 76 lbs/a. The lodging score ranged from 7% (control) to 60% (140 lbs N/a).

### **Conclusion**

From first year study, we can safely conclude that a bushel of oat grain was achieved by much less available N than our current recommendation of 1.3 lbs. Applying PGR consistently reduced height and lodging at both locations which could be used as a tool along with variety selection for better plant standability.

### **Project Budget**

In the first year, we expended about \$20,000 to complete the above tasks.

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### Background

The fertilizer recommendations guide for South Dakota (SD) crops was last updated in 2005 (EC750, 2005), and the nitrogen (N) recommendations for the oat grain crop are higher than guidelines recommended by other public institutions. The SD guideline uses expected yield goal to be multiplied by 1.3 (minus soil test N and legume credit) to estimate total N requirement by the oat crop. Perhaps, due to improved genetics and other management tools, producers in productive environments have consistently grown oat crop with yield of more than 100 bu/a with significantly lower levels of nitrogen than recommended in the EC750 guide. The proposed study aims at developing an up-to-date nitrogen fertilizer recommendation for oats grown for grain production in SD. This will help narrow the knowledge gap among oat growers in terms of applying the correct amount of nitrogen fertilizer on oat crops to maximize production and profitability, and avoid lodging. Sharing results from each growing season in the form of web articles (igrow.org), fact sheets/publications, summer field days, winter crop meetings, and events organized by other education groups such as USDA-NRCS will effectively impact the decision making for oats producers in SD and surrounding regions. Application of fertilizer N as required by the crops will benefit growers to obtain highest yield potential without negative impact on environment.

### Goal and Objectives:

The goal of the proposed study is to develop a revised nitrogen fertilizer recommendation for oat grown for grain production in SD environments. The objective of this study is to determine oat yield response to varying levels of applied nitrogen fertilizer. Some SD growers have shown interest in using plant growth regulators (PGR) to shorten plant height as a mean to prevent lodging. In one or more location, we used both growth regulator and nitrogen levels as treatments. This will allow us to see if there is any financial benefit of using growth regulator to increase grain yield by applying higher N rates without potential crop lodging.

### **2019 Growing Season**

*Performance of Oats under different Nitrogen Regimes when grown with and without Plant Growth Regulator (PGR)*

In 2019, the trials that consisted PGR (Palisade by Syngenta) as an added variable were conducted at the SDSU Southeast and Northeast Research Farms near Beresford and South Shore, SD. However, due to excess moisture it was not feasible to apply Palisade at SE farm. Therefore, we considered SE to be an additional site for testing nitrogen rates. A total of five N rates (20, 40, 60, 100 and 140 lbs/a) were used in the study with additional 'control' treatment which did not receive any nitrogen. At planting

NE farm had about 80 lbs/a available N (40 lbs in soil and 40 lbs soybean legume credit) and SE farm had 88 lbs/a available N at planting. A split plot design was used with N treatment as the main factor and growth regulator the split factor. All treatments were arranged in Randomized Complete Block (RCB) design with three replicates. The plot size was 15' x 30'. Both sites were planted to variety 'Saddle' in 2019. At NE farm due to standing water immediately after planting, one range (about 9 plots) had poor emergence.

Two other locations- Aurora Research Farm (variety Saddle) and farmer cooperator's field in Garretson (variety Hayden) were used to test nitrogen rates without the application of PGR. At the beginning of the season we had planned to add two more locations- Salem and Miller, however due consistent precipitation in the spring we could not continue beyond soil sampling at these sites.

## **Results:**

### ***Effects of N Rates on Oat Performance in 2018 Growing Season***

The average grain yields were inferior to previous test years. At SE farm, the yield ranged from 30 bu/a (60 lbs N) to 55 bu/a (100 lbs N) whereas, at Aurora and Garretson the yields ranged from 87 bu/a (control) to 113 bu/a (20 lbs N) and 67 bu/a (control) to 94 bu/a (60 lbs N) respectively. The rates did not show significant effects on lodging and plant height.

### ***Effects of N Rates and Plant Growth Regulator on Oat Performance in 2018 Growing Season***

In 2019 the Palisade treatment was only tested at NE farm. It was applied at 14 oz/a with at least 15 gallon of water at Feekes 6 growth stage (1<sup>st</sup> node visible). The label states for 10.5 to 14.4 oz per acre from Feekes 4 (leaf sheath strengthening) to Feekes 7 (2<sup>nd</sup> node visible) growth stages. The total available N (legume credit + soil test N) prior to the application was 80 lbs/a.

The average yields ranged from 75 bu/a (control plot with Palisade) to 113 bu/a (140 lbs N with no Palisade). Due to weather factors and comparatively lower yields than in usual year, we did not notice much lodging at the site, however, the PGR showed significant effects on plant height.

### ***Grain Quality Parameters***

Sub-samples taken from each plot from all test sites were run for several grain quality parameter at the General Mills laboratory. Among the sites tested for nitrogen rates (i.e. Aurora, SE Farm, and Garretson), only grain protein content from Garretson samples showed significant response to applied nitrogen. All other quality measures such as plump grain, thin grain, percent groat, beta glucan, and fatty acid content did not show significant response to applied nitrogen at these sites.

At NE farm, we added plant growth regulator a variable in addition to nitrogen rates. Plant growth regulator (PGR) showed significant response to following grain quality parameters- protein content and grain plumpness. However, nitrogen rates showed significant effects on protein content and percent goat.

### **Conclusion**

The PGR used in this study was able to significantly reduce height and in rare cases lodging (on plot wise basis) on oat crop. Generally, the 'control' plots yielded lower than the nitrogen treated plots. In most cases lower range of nitrogen rates were able to produce the optimum yields which suggests that our current recommendation of 1.3 lbs N/bu oats is higher than possibly required by the crop. After completion of proposed three years study, all obtained yield data will be pooled to accurately estimate the recommended N rate for oats in SD environments.

### **Acknowledgment**

Authors like to express sincere gratitude to SD Nutrient Research and Education Council for funding this project. We also like to thank General Mills for assisting with grain quality assessment.

## **Calibration of Nitrogen Requirement of Oats Grown for Grain in South Dakota**

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### Background

The fertilizer recommendations guide for South Dakota (SD) crops was last updated in 2005 (EC750, 2005), and the nitrogen (N) recommendations for the oat grain crop are higher than guidelines recommended by other public institutions. The SD guideline uses expected yield goal to be multiplied by 1.3 (minus soil test N and legume credit) to estimate total N requirement by the oat crop. Perhaps, due to improved genetics and other management tools, producers in productive environments have consistently grown oat crop with yield of more than 100 bu/a with significantly lower levels of nitrogen than recommended in the EC750 guide. The proposed study aims at developing an up-to-date nitrogen fertilizer recommendation for oats grown for grain production in SD. This will help narrow the knowledge gap among oat growers in terms of applying the correct amount of nitrogen fertilizer on oat crops to maximize production and profitability, and avoid lodging. Sharing results from each growing season in the form of web articles (igrow.org), fact sheets/publications, summer field days, winter crop meetings, and events organized by other education groups such as USDA-NRCS will effectively impact the decision making for oats producers in SD and surrounding regions. Application of fertilizer N as required by the crops will benefit growers to obtain highest yield potential without negative impact on environment.

### Goal and Objectives:

The goal of the proposed study is to develop a revised nitrogen fertilizer recommendation for oat grown for grain production in SD environments. The objective of this study is to determine oat yield response to varying levels of applied nitrogen fertilizer. Some SD growers have shown interest in using plant growth regulators (PGR) to shorten plant height as a mean to prevent lodging. In one or more location, we used both growth regulator and nitrogen levels as treatments. This will allow us to see if there is any financial benefit of using growth regulator to increase grain yield by applying higher N rates without potential crop lodging.

### **2020 Growing Season- Covid19 Updates**

Although, the project generally was not impacted by COVID-19 pandemic, we did lose one farmer cooperator's site due to travel restriction early in the season. This year, we had three SDSU Research Farms (Aurora, Northeast, and Southeast) and two farmer cooperators fields in Buffalo and Minnehaha County. Due to travel restrictions, initial fertilizer treatments (at planting) were applied by the Research Farms and farmer cooperators. In addition to nitrogen fertilizer, plant growth regulator (PGR) Palisade was applied at SDSU NE and SE farms this year.



*Performance of Oats under different Nitrogen Regimes when grown with and without Plant Growth Regulator (PGR)*

In 2020, the trials that consisted PGR (Palisade by Syngenta) as an added variable were conducted at the SDSU Southeast and Northeast Research Farms near Beresford and South Shore. A total of five N rates (20, 40, 60, 100 and 140 lbs/a) were used in the study with additional 'control' treatment which did not receive any nitrogen. At planting NE farm had about 90 lbs/a available N (50 lbs in soil and 40 lbs soybean legume credit) and SE farm had 70 lbs/a available N at planting. A split plot design was used with N treatment as the main factor and growth regulator the split factor. All treatments were arranged in Randomized Complete Block (RCB) design with three replicates. The plot size was 15' x 30'. Both sites were planted to variety 'Saddle' in 2020.

Extremely high temperatures, high winds, and significantly less rainfall, especially at the SE farm is reflected on grain yield. The yields were significantly lower than other locations and ranged from 62 bu/a (100 lbs N/a) to 80 bu/a (20 lbs N/a). The applied N rate showed significant effects on grain yield and PGR showed significant effects on plant height. The average plant height for PGR treated plots was 21.5 inches and 29.4 inches for the non-PGR plots. Contrary to the SE farm, the yields at NE farm were far superior because of intermittent rainfall during hot and dry period during the growing season. The yield did not get significantly affected by either applied N rate or the PGR. The average grain yield ranged from 137 bu/a (control) to 157 (140 lbs/N). Although the average yield was highest for 140 lbs N/a, yields were very similar for all N treated plots and were easily distinguishable from control plots. The average height of PGR treated plots was 28 inches whereas the non-PGR plots had the average plant height of 34.2 inches.

**Results:**

***Effects of N Rates on Oat Performance in 2018 Growing Season***

Three other locations- Aurora Research Farm (Advanced Line SD140741), and farmer cooperators' fields in Garretson (variety Hayden) and Chamberlain (variety Hayden) were used to test nitrogen rates without the application of PGR. At the beginning of the season we had planned one more site but due to the pandemic we were not able to continue at that location.

Since the beginning of the project in 2018 we were testing our objectives on soybean residue, however, this year at Chamberlain, we had an opportunity to grow oats on corn residue. NOTE: The rotation was never imposed, rather followed what was already in place at the research farm or cooperators' fields.

Due to extremely hot weather and significantly below average rainfall, especially in June at Aurora and Garretson, the average grain yields were inferior to other sites. Although

not in high amounts, Chamberlain site had some minor rain events which resulted in better yield.

The N rate did not show any significant effects on yield at Aurora and Garretson, however, in Chamberlain the yield was significantly affected by applied N rate. The average yields for the applied treatments ranged from 63 bu/a (100 lbs N/a) to 86 bu/a (40 lbs N/a) at Aurora and 73 bu/a (100 lbs N/a) to 90 bu/a (40 lbs N/a) at Garretson. Similarly, the yield ranged from 127 bu/a (control) to 149 (40 lbs N/a). At Chamberlain, all N applied yields were similar and could be easily distinguishable from the control plots.

### ***Grain Quality Parameters***

The samples were analyzed for various grain quality parameters at the General Mills laboratory. At Aurora location, protein and beta-glucan content showed significant response to applied nitrogen. The response of grain protein to applied nitrogen was observed in few sites in previous years, however, nitrogen effects on beta-glucan content was neither observed in the previous years nor this year at other sites. This could have been attributed to other unpredictable variables such as weather rather than applied N treatments.

Grain quality parameters determined were- protein content, plumpness (%), fat (%), and groat (%). Applied nitrogen and PGR treatments did not show any significant effects on the measured quality parameters.

### **Conclusion**

The PGR used in this study was able to significantly reduce height. Due stressful growing conditions, plants did not show aggressive vegetative growth to see any significant lodging. Generally, the 'control' plots yielded lower than the nitrogen treated plots. Extremely dry sites like Aurora, Garretson, and SE farm utilized more N than usual for plant growth and production. Soil residue N was also higher for these sites. However, at Chamberlain site, the N use efficiency is higher and 40 lbs N/a plots yielded the highest. Even in extremely warm and dry year like this the ratio of N to grain yield was lower than the current recommendation of 1.3.

Generally, the PGR and Nitrogen did not show any effects on grain quality parameters

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### Results:

#### ***Performance of Oats under different Nitrogen Regimes when grown with and without Plant Growth Regulator (PGR)***

In 2021, only one site NE Res Farm was used to test PGR 'Palisade'. A total of five N rates (20, 40, 60, 100 and 140 lbs/a) were used in the study with additional 'control' treatment which did not receive any nitrogen. At planting, NE farm had about 94 lbs/a of available N (54 lbs in soil and 40 lbs soybean legume credit) A split plot design was used with N treatment as the main factor and growth regulator the split factor. All treatments were arranged in Randomized Complete Block (RCB) design with three

replicates. The plot size was 15' x 30'. Both sites were planted to variety 'Saddle' in 2020.

Extremely high temperatures, especially whole month of June coupled with high winds and practically 'zero' rainfall significantly affected the overall plant performance. The grain yield range was extremely narrow and ranged from 67 bu/ac (60 lbs N with Palisade) to 77 bu/ac (140 lbs N no Palisade). There was no significant response from added N and the check plots performed as well as other treated plots. The ratio of applied N and grain yields ranged from 0.7 (check) to 2.5 (140 lbs N) which suggests that 0.7 lbs N per bushel of grain was the optimum required N for this site in 2021.

Unlike previous years, the plants were extremely short and PGR did not show statistically significant effects on plant height. However, in an average PGR shortened the plant height by about 3 inches.

### ***Effects of N Rates***

Six additional locations Brookings Research Farm (Plant Pathology Farm), SE Res Farm, farmer cooperators fields in Garretson, Hand, Hyde, and McCook Counties were used for the study. We lost two sites in Hand and McCook Counties. At Hand Co. near Miller, the cooperator spread fertilizer on the trial area as well and in McCook Co. near Salem, the producer hayed the field in June due to extreme drought. All sites except Hyde Co. near Highmore had soybean residue on the fields. The Highmore site was previously planted to sunflower.

The SE Res Farm site was originally planned for 'PGR' test as well but due to rapid plant growth, the PGR application window was missed. Therefore, we used this site as N rate site. At SE Farm, the yields ranged from 69 bu/a (140 lbs N) to 78 (60 lbs N). The 'check' treatment yielded 70 bu/a. The yields did not show any significant differences for the applied N treatments. The ratio of N and grain yield ranged from 0.7 (check) to 2.8 (140 lbs N/a) and non-significant response suggests that 0.7 lbs of N would be optimum amount for obtaining a bushel of grain.

At Minnehaha Co. near Garretson, the yield ranged from 83 bu/a (check) to 87 (100 lbs N) did not show any significant response to applied N treatments. The pre-trial soil test N including legume credit was 50 lbs/a. The ratio of total N to grain yield ranged from 0.6 to 2.2 with optimum required N of 0.6 lbs for one bushel of grain. The response was similar at Brookings location with non-significant N rate effects on grain yield that ranged from 105 bu/a (check) to 115 (100 lbs N/a). The ratio of total N and grain yield ranged from 0.6 to 1.9 with 0.6 lbs N/a to be the optimum required N to yield a bushel of grain.

The Highmore site was slightly unusual because this is the only site which did not have soybean as previous crop. The field was planted to sunflower in 2020 season. The pre-trial soil test N was 23 lbs N/a. The grain yields ranged from 75 bu/a (check) to 96 bu/a

(100 lbs). At this site, yields were significantly different for applied N treatments with 40 lbs N/a to the optimum applied rate. The ratio of total N and grain yield ranged from 0.3 to 1.9 with 0.7 (for 40 lbs applied N) be the optimum required to produce a bushel of grain.

### **Conclusion**

Although extremely short plants due to water stress and high temperatures, the PGR was still able to reduce the height of about 3 inches in average, however the effect was statistically non-significant. The 2021 data from N rate sites suggest that optimum (and economical) rate of N required to produce a bushel of oat is about 0.7 lbs N/a. Due to stressful growing conditions, we lost two sites this year and the sites that were able to be harvested had much lower yields than previous study years.

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### Results:

#### ***Performance of Oats under different Nitrogen Regimes when grown with and without Plant Growth Regulator (PGR)***

In 2022, two sites NE Res Farm and SE Res Farm were used to test PGR 'Palisade' along with N treatments. A total of five N rates (20, 40, 60, 100 and 140 lbs/a) were used in the study with additional 'control' treatment which did not receive any nitrogen. At planting, NE farm had about 95 lbs/a of total available N (55 lbs in soil and 40 lbs soybean legume credit). At SE farm, total available N at planting was about 90 lbs. A split plot design was used with N treatment as the main factor and growth regulator the

split factor. All treatments were arranged in Randomized Complete Block (RCB) design with three replicates. The plot size was 15' x 30'. Both sites were planted to variety 'Saddle'.

Extremely dry conditions, especially at SE affected plant growth and shortened plant height. As a result we did not see true effects of PGR on plant height. These weather conditions also affected grain yield. The average grain yield at the SE farm was 67 bu/a (65 bu/a for PGR treated and 69 bu/a for non-PGR plots). On the contrary NE farm sustained better with spring moisture, however, two strong storms close to ripening lodged creating significant yield loss on all plots. The average yield for PGR treated plots was 87 bu/a and non-PGR plots was 89 bu/a. The PGR consistently shortened the plant height by 5 inches at NE farm. The N treatment did not show significant effects on grain yield at both sites, which suggests that the soil available N at planting was enough for the obtained grain yield in 2022.

### ***Effects of N Rates***

Four additional locations Aurora Research Farm, and three farmer cooperators fields in Garretson, Gann Valley, and Salem were used to test the effects of N rate. All sites except Garretson were affected by widespread drought and grain yields were well below average. Salem site was affected twice by high winds during two derecho events.

We did not see significant N rate effects on grain yield at Aurora, Gann Valley, and Salem, however, at Garretson the 'check' plots were significantly different than all treated plots. The pre-trial total soil available N (soil plus legume credit) at Aurora, Garretson, Gann Valley and Salem were 95 lbs/a, 80 lbs/a, 41 lbs/a, and 140 lbs/a respectively. All sites except Gann Valley (corn residue) were on soybean residue. The average yields for each site were 100 bu/a (Aurora), 150 bu/a (Garretson), 65 bu/a (Gann Valley), and 109 bu/a (Salem). The non-significant effects of N rate on grain yield suggests that soil available N was enough to obtain the optimal yield at each site except Garretson. At Garretson, the lowest applied N of 20 lbs/a was able to match the yields from 40 lbs/a, 60 lbs/a, and 140 lbs/a. The 100 lbs/a rate had the highest yield of 167 bu/a and was significantly different from other treatments. The check plot yield was 116 bu/a at Garretson.

### **Conclusion**

The 2022 data from N rate sites suggest that optimum (and economical) rate of N required to produce a bushel of oat is significantly lesser than current recommendation of 1.3 lbs/bu. Due to stressful growing conditions, all sites except Garretson had below average grain yield.

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