Carrington Research Extension Center

NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

A Report of Agricultural Research and Extension in Central North Dakota

Photo by Suanne Kallis, Carrington REC

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Research Highlights from 2021

Crop Variety Comparison Data

The Carrington Research Extension Center conducts research and educational programs to enhance the productivity, competitiveness, and diversity of agriculture in central North Dakota. Research activities at the CREC include scientists and support staff trained in and implementing programs in Agronomy, Plant Pathology, Soil Science, Precision Agriculture and Animal Science. These program teams are able to address a broad scope of factors that impact North Dakota agriculture. The crop diversity of the state is addressed in all program areas and is further supported by the ability to conduct research under both dryland and irrigated conditions. Projects addressing organic crop production and a fruit and berry program broaden the constituency being served. The foundation seed program of the Center represents an important part of the overall NDSU Foundation Seed program. The CREC is the base of operation for four Extension specialists. This report highlights a portion of the department's contributions to research and extension. Following are a few examples of highlights from our past season and significant impacts and contributions to the region's agriculture.

In 2021, a study was implemented to look at irrigation and no irrigation on drought-tolerant corn hybrids. The severity of the drought in 2021 overwhelmed these hybrid's abilities to produce yields that match the production of full irrigation in well-drained soils. Future studies will evaluate irrigation rates to measure the value of drought-tolerant traits.

The NDSU Extension Livestock Specialist Team was integral in drought response efforts during the 2021 growing season. Besides hosting in-service opportunities for Extension agents and helping develop a number of resources, they also hosted two drought-related webinar series. As a result of the Navigating Drought on Your Ranch webinar series hosted live from the NDSU Carrington Research Extension Center from April through October 2021, a total of 28 unique participants have made changes impacting over 93,555 acres of grazing land and 7,300 head of livestock (see page 5).

Canola studies were aimed at determining whether fertilizer efficiency can be improved by split applications of nitrogen (N) fertilizer, topdressing sulfur (S), or by lowering S rates from 20 to 10 lbs/ac. From the results, farmers are less likely to see yield and economic benefits of split N application than applying once at planting. Results also show farmers should apply preplant sulfur rather than waiting to topdress.

Demonstrated that yield gains from fungicide applications targeting white mold in soybeans can be increased by 50 to 100% when fungicide droplet size is calibrated relative to canopy characteristics and nozzle manufacturer. With TeeJet extended-range, flat-fan nozzles, fine to medium droplets optimized soybean yield when the canopy was very open (average < 75% closure), medium droplets were optimal when canopy closure averaged 80 to 89%, and coarse droplets were optimal with canopy at or near closure (average 92 to 100% closure). With Wilger Combo-jet, flat-fan nozzles, coarse droplets optimized yield when the canopy was open (average <80% closure) and very coarse droplets optimized white mold management when the canopy was at or near closure (95-100%). Growers who have adopted these techniques have reported sharp improvements in fungicide performance against white mold in soybeans.

Investigated various aspects of wide-row corn including in-season cover crop growth, differences in yield between different hybrids planted in 30-inch rows, differences in population, and weed control. The trials have shown a small but significant decrease in yield in some hybrids. The cover crop trials have shown increased growth of cover crops in the 60-inch rows vs. 30-inch rows. Weed pressure has been higher in 60-inch rows.

The Northern Hardy Fruit Evaluation Project provided distance learning for approximately 900 people through videos and webinars. Our in-person field day was attended by 55 people. We served over 130 producers and educators in North Dakota, Nebraska, South Dakota, Minnesota, Montana, Kentucky and Alaska through calls and email.

Completed multi-location, multi-year studies demonstrating that pinto bean yield is maximized in narrow rows (7.5 to 15-inch) when white mold severity is moderate (less than 20% of the canopy diseased at the end of the season) and that wide rows (30 inches) only maximize pinto bean agronomic performance when white mold pressure is high (more than 20% of the canopy diseased).

In cooperation with University of Minnesota Extension, NDSU Extension co-hosted two manure composting workshops in the summer of 2021. These workshops were the hands-on version of the online workshops offered in 2020 and supported by North Central SARE. One hundred percent of the survey respondents strongly agreed or agreed that the workshop was valuable and worthwhile. Seventy-two percent of those respondents strongly agreed or agreed that they will change their manure composting practices based on information gained from the workshops.

The CREC continues to evaluate forage production to provide information on forages available to producers in central North Dakota. The Center has evaluated many types of forages ranging from cool-season annual cereals and legumes, warm-season annual grasses, winter annual cereals, and alfalfa. Results from these trials provide information to producers on crop selection and variety choice. New this year, the Center evaluated corn silage hybrids providing performance data from dryland and irrigated environments.

Field trials were conducted to determine if, and which, enhanced efficiency nitrogen (EEN) fertilizers would have significant impact on grain yields and be less expensive for farmers. Yields and protein were not different between the different sources of N, indicating that farmers would be better off not spending money on the more expensive EEN fertilizers if prevailing field or weather conditions are not likely to cause significant loss of N (see page 28).

Evaluated the potential of differing roughage sources on feedlot performance and metabolism in steers. Results of this study indicated that grass hay and corn silage roughage source diets had greater hot carcass weights than those fed beet pulp. Also, backfat was thicker for steers fed corn silage compared to those fed beet pulp. There were no differences in ribeye area, marbling, quality grade, yield grade or ruminal pH due to roughage source (see page 33).

Demonstrated that field pea agronomic performance can be sharply improved in fields with significant Fusarium and Aphanomyces root rot pressure through the combined use of long crop rotations (planting peas or lentils a maximum of once every 6 years), planting when soils are cool (optimal soil temperature of 45.5 to 50°F at a 2-inch seeding depth in the seven days after planting), and the use of a fungicide seed treatment with efficacy against Pythium and Rhizoctonia root rot. Recommendations were developed from 16 planting date studies conducted across six locations in central and western North Dakota from 2017 to 2020. The planting date studies demonstrated sharp, statistically significant increases in Fusarium and Aphanomyces root rot severity as average soil temperature in the 7 days after planting increased from 39 to 55°F. The data have resulted in producers changing the long-standing practice of planting field peas late in fields where Fusarium and Aphanomyces root rots are a concern.

Through collaboration with the NDSU Soybean Breeding Program, 1,650 soybean plots with experimental varieties were successfully harvested in 2021. This effort represents a large geographical region in the heart of soybean acreage in the state. The collaboration is part of the process that leads to the selection of elite performing cultivars that will one day be released as public varieties that are adapted to our region.

A series of virtual crop production meetings was organized and conducted by NDSU Extension in cooperation with North Dakota commodity organizations during February and March 2021. Four 'Getting-it-Right' Zoom meetings on dry bean, soybean, canola and flax provided farmers and crop advisers with current NDSU production research and recommendations. A total of over 500 people participated in the meetings, and evaluations indicated that generally, 70% or greater of respondents indicated learning new information or information is intended to be applied to farm management.

Foundation seedstock staff grew 28 varieties of seven different crops in 2021, including released and pre-release varieties. Newer varieties for distribution in 2022 include two barleys, two flaxes, one spring wheat, and two soybeans. Our diversity of crops that are grown (barley, durum, field pea, flax, soybean, spring wheat and winter rye) represents the seedstocks that are sought on a yearly basis by growers.

Generated new sorghum germplasm through crosses between short-maturity, cold-tolerant parents. Thirty previous sorghum crosses were field tested for suitability to North Dakota. Yields of the new lines ranged from 60 to 150 bu/ac compared to nearby corn trials which averaged roughly 65 bu/ac. The sorghum is intended to be released in the future as a drought-tolerant cropping option for Northern Great Plains farmers.

In an effort to combat saline soil introgression, 35 public and private varieties of sunflower, canola, and spring wheat were screened to determine any differential response to salinity. Results will be used to modify planting recommendations to improve crop performance in marginal land, increasing productivity and reducing economic loss in those areas.

Developed novel mobile applications to streamline many UAV (drone) activities such as maintaining flight logs, monitoring weeds, and accessing on-the-go trial information. These applications may offer producers a methodology for streamlining field-based data collection. Mobile applications for data collection reduce potential error associated with transcribing handwritten notes and provide real-time updates.

The CREC has coordinated winter rye variety testing across the NDSU Research Extension Centers and winter rye variety development for a number of years. The state-wide testing system is important to give producers current information on rye variety selection across the various regions of the state. This year the CREC initiated uniform variety testing of buckwheat and lupin at a number of NDSU research sites. This network of testing for specialty crops is needed to give producers timely information of best management practices.

NDSU Extension Webinars Facilitate Adaptation of Drought Management Strategies

Miranda A. Meehan, Mary A. Keena and Kevin K. Sedivec

During the 2021 growing season, all of North Dakota experienced some level of drought. The drought started in the fall of 2020 and developed into one of the most severe droughts on record. To aid ranchers in developing drought plans and navigate the on-going drought, NDSU Extension specialists hosted webinars. The drought webinars provided timely information to aid ranchers in the development of drought management plans and strategies for their ranches.

Introduction

In the 2021 growing season, all of North Dakota experienced some level of drought. Extreme drought (D3) and exceptional drought (D4) started on March 18 and May 20, respectively. This is the earliest these conditions have been introduced during the growing season since the inception of the U.S. drought monitor in 2000.

Behind the scenes look at hosting one of the drought webinars at CREC.

Having a plan in place, with well-defined trigger dates for implementing drought management strategies, helps ranchers get through the drought and minimize losses. The longer ranchers wait to make management decisions, the fewer options available and the greater risk of overgrazing, reduced livestock performance, the need to sell or cull more animals, and greater chance economic losses will occur.

To aid ranchers in developing drought plans and navigate the on-going drought, NDSU Extension specialists hosted webinars. In February and March, they hosted a series focused on preparing for drought, followed by an on-going monthly webinar focused on strategies to address drought at the ranch level.

Procedures

In February 2021, NDSU Extension initiated a webinar series focused on preparing a ranch for drought. This series included six sessions. The topics included drought trigger dates, grazing strategies, supplemental feed options, livestock water, herd management and managing stress during drought. The series was broadcast live to 140 individuals from four countries and fifteen states and the videos have been viewed 1,293 times.

Due to the on-going drought conditions, NDSU Extension continued to host a monthly webinar series from May through October of 2021. These webinars provided ranchers and land managers with drought outlooks and potential management strategies to consider as the drought progressed. The series was broadcast live to 73 individuals from five countries and ten states, while the videos have been viewed 1,012 times.

Registration and polls were used to assess characteristics of the audience, intent to make changes and the potential impact of the webinars. Data was collected to determine if management changes were made by individuals that attended the planning series and registered for the navigating drought series. In addition, a follow-up survey was sent to all registrants of both series to track the development of drought plans and implementation of drought management strategies.

Results

The audience for both webinar series consisted of a broad range of attendees including producers, Extension personnel and personnel from government agencies.

Overall, participants indicated that the "Preparing for Drought" series increased their knowledge of the topics covered (Figure 1). A total of 53 unique participants intended to make management changes impacting over 36,000 acres of grazing land and 6,000 head of livestock.

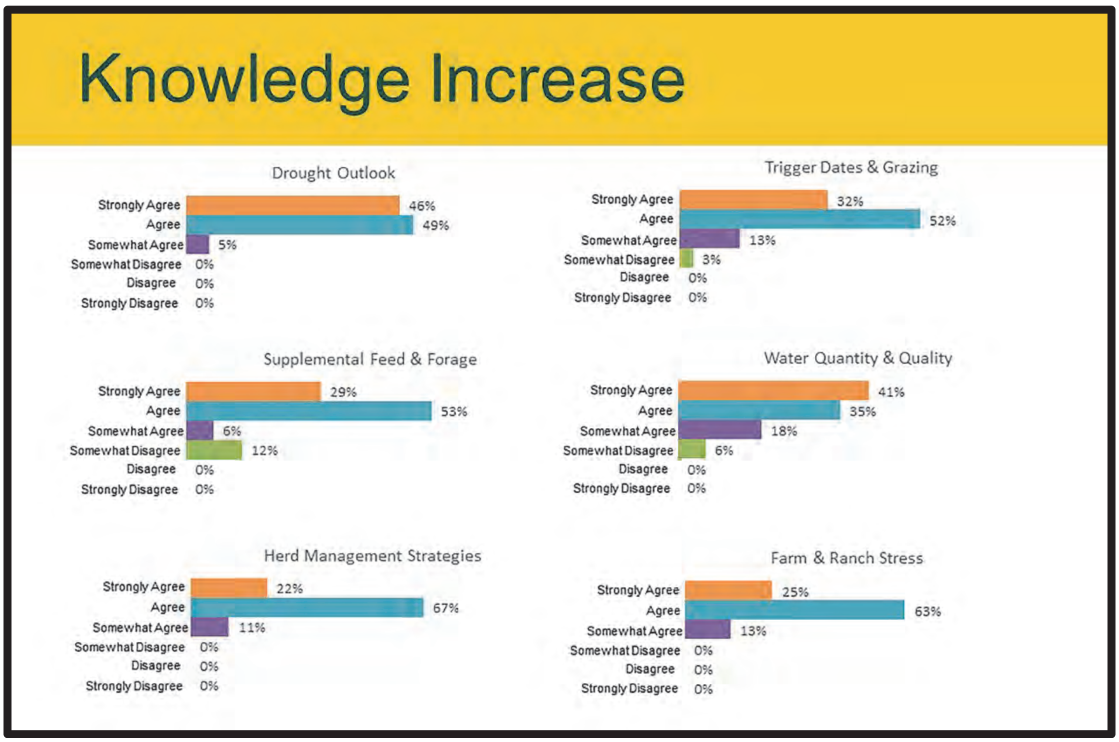

Figure 1. Participant rating of knowledge increase for the six sessions in the Preparing Your Ranch for Drought webinar series.

Of the 141 individuals who registered for the "Navigating Drought on Your Ranch" webinars, 31 attended the Preparing Your Ranch for Drought webinars. During the Preparing Your Ranch for Drought planning series, seven (25%) of these individuals indicated they had a drought plan. Following the series, 8 (29%) additional participants implemented a drought plan.

All of the participants in the "Navigating Drought on Your Ranch" webinar series indicated they increased their knowledge of the topics covered. A total of 28 unique participants reported making management changes impacting over 7,300 head of livestock and 93,555 acres of grazing land. In addition, 14 unique participants intended to make changes potentially impacting an additional 2,003 head of livestock and 12,708 acres of grazing land.

Following the completion of both webinar series, a follow-up survey was sent to 292 registrants to track the development of drought plans and implementation of drought management strategies. Forty-five individuals completed the follow-up survey. A total of 20 respondents indicated they made management changes based on the information shared during the webinars, impacting 4,526 head of livestock grazing 45,425 acres. Common management changes reported by respondents included adapting grazing systems, adjusting stocking rates, purchasing supplemental feed, monitoring water and feed quality and implementing strategic culling strategies. A total of 19 respondents indicated they created a new drought plan or updated an existing drought plan following the webinars, enabling them to make more timely management decisions.

The drought webinars hosted by NDSU Extension provided timely information to aid ranchers in the development of drought management plans and strategies for their ranches. The recordings from these webinars are available at https://youtube.com/playlist?list=PLnn8HanJ32l5O6GSBv5b2sdweInbmcn5T.

Acknowledgments
Thank you to all those who presented or were panelists for these webinars including Adnan Akyuz, Karl Hoppe, Nathan Spickler, Gerald Stokka, Janna Block, Lisa Pederson, Travis Hoffman, Sean Brotherson, Andrea Bowman, Charles Stoltenow, Philip Estepp, Becky Kopp-Dunham, Lilah Krebs, Zac Carlson, Ron Haugen, and Tim Petry. Thank you to Linda Schuster and Scott Swanson for their technical support.

Development of Hardy White Grain Sorghum Cultivars

Mike Ostlie, Melissa Hafner, and Harley Burgard

In 2021, many parts of North Dakota experienced one of the worst droughts on record. Some forecasts call for an extended period of drought into the next year or more. While several crops in the region handle drought stress well, others do not. Sorghum is a tropical plant that produces grain with less water and nitrogen compared to a crop like corn. Due to its tropical nature, it is also very sensitive to frost damage. Historically, North Dakota is the northern limit in which sorghum production can occur. Currently there are no nearby sorghum breeding programs in the US. The majority of commercial sorghum hybrids available in suitable maturities are bred for double-crop applications in southern states. The good news is that we have tested sorghum cultivars at the Carrington Research Extension Center and Oakes Irrigation Research Site every year since 2016. There are commercial hybrids that will mature within our frost-free days. The exception is that commercial *white* sorghum types have not always made it to maturity. White sorghums are desirable for several reasons, but the most common use is as a food ingredient (ex. gluten-free flour). This market can command a premium compared to other sorghum colors which are primarily used as livestock feed.

In an effort to increase cropping options for North Dakota a sorghum breeding project was initiated in 2016. The initial goal was to identify white sorghum lines from around the world that are early maturing and pollinate under cool temperatures. The initial screening contained 175 lines. The first year was a good year for sorghum and around 80% of the lines produced viable seed. Data were collected for days to flowering, height, grain fill, and yield potential. These filters were used to narrow the possibilities down to a dozen of the best lines, while a handful of unique plant types were retained as a source of diversity. These lines were tested in the field in 2017 to confirm adaptation. In the winter of 2018, crosses were made between many sets of good performing material. These lines were increased in the greenhouse during the winter of 2019 and tested in the field for the first time in 2021.

Grain sorghum nursery in July 2021.

There were 40 crosses and elite parents tested in the field in 2021. The populations proved to be highly segregating for a variety of traits. Nevertheless, it was the first time meaningful yield data from the crosses was collected. The best individual plants from each plot were selected and will be used to create uniform populations for future variety development. Concurrently, a second set of crosses was made in the greenhouse in the winter of 2021 between parents that were not mated in the first set of crosses. These plants will undergo a similar process as above.

Even though the populations were segregating and yield will likely improve, this was a good performance benchmark. The study included two replications of each line as well as a commercial hybrid check. Yields in the trial ranged from 59 bu/ac to 136 bu/ac with an average of 92.8 bu/ac. The commercial check yielded 115.9 bu/ac, which was the fourth best value. To be fair, the commercial check had a much higher yield potential, but it did not quite mature fully at harvest. Given the dry conditions this year, these yields are exceptional. Consider that in this region, these yields would top barley on a good year and match oats on a good year. Average corn yields should easily top this sorghum production, however, in 2021 the average yield in nearby corn trials was only 61 bu/ac.

Experimental white sorghum near maturity.

There is still much work to be done towards commercialization and release of a new variety (minimum of 5 years). To summarize, the sorghum breeding project at CREC has good material in the pipeline that may be suitable to use as an open-pollinated variety, or screened for use as an in-bred line in hybrid seed production. Potential uses for the sorghum are as a gluten-free food, drought resistant livestock feed, or as cover for remediation sites and wildlife habitat.

Optimizing Row Spacing and Seeding Rate for Improved Pinto Bean and Kidney Bean Agronomic Performance Under White Mold Disease Pressure

Michael Wunsch

Planting pinto and kidney beans to narrow rows is known to maximize pinto bean yields in the absence of white mold, but worries about white mold have limited the adoption of narrow rows.

In 2019 and 2020, the plant pathology program at the Carrington Research Extension Center, in conjunction with the agronomists at the Oakes Irrigation Research Site, evaluated the impact of seeding rate and row spacing on agronomic performance of pinto beans under white mold disease pressure. Testing was done with 'Palomino' and 'Vibrant' slow-darkening pinto beans and 'Rosie' light-red kidney beans, 'Dynasty' dark-red kidney beans, and 'Pink Panther' light-red kidney beans. To assess the impact of row spacing and seeding rate under different levels of disease pressure, testing was done with no foliar fungicide, with a single fungicide application at early bloom (Topsin at 40 fl oz/ac), with two sequential fungicide applications (Topsin at 40 fl oz/ac followed by Endura at 8 oz/ac), or with pinto beans seeded into a rye cover crop terminated either 10-14 days before planting or 0-3 days after planting. Plots were 10 feet wide by 25 feet long, with the middle 5 feet by 20 feet harvested for yield. All studies were conducted with six replicates. Overhead irrigation was applied as needed to create conditions favorable for white mold. White mold was assessed shortly before or at maturity. Within each plot, a third to half of the plants were individually assessed for white mold severity.

The row spacing that optimized pinto bean agronomic performance was contingent on white mold disease pressure (Figure 1). When white mold pressure was low to moderate (less than 20% in 30-inch rows), pinto bean yield was maximized in narrow (7.5- or 15-inch) rows. The yield gain associated with earlier canopy closure and the resulting increase in photosynthesis was greater than the reduction in yield associated with the modest increase in white mold pressure associated with narrower rows. When white mold yield was high (more than 20% in 30-inch rows), pinto bean yield was similar across row spacings, and pinto bean agronomic performance was optimized in wide (30-inch) rows. Disease was lower in the 30-inch rows, and the reduction in white mold observed in wide rows reduces seed quality problems (primarily moldy seed and sclerotia contamination).

WHITE MOLD SEVERITY (% of canopy)

Row spacing (inches)	Seeding rate, pure live (viable) seeds (pls/ac)	Pinto beans: Plant population, end-of-season (at maturity) (plants/ac)	Pinto beans: Low disease pressure, <20% of canopy (30-inch rows), 12 studies	Pinto beans: Intermediate disease pressure, 20-40% of canopy (30-inch rows), 8 studies	Pinto beans: High disease pressure, >40% of canopy (30-inch rows), 7 studies	Kidney beans: Plant population, end-of-season (at maturity) (plants/ac)	Kidney beans: Low disease pressure, <20% of canopy (30-inch rows), 6 studies	Kidney beans: Intermediate disease pressure, 20-40% of canopy (30-inch rows), 5 studies	Kidney beans: High disease pressure, >40% of canopy (30-inch rows), 7 studies
30	70,000	50,894	9 a	29 a	53 a	52,559	5 ab	34 a	46 a
22.5	70,000	52,427	11 ab	36 ab	60 a	50,606	4 ab	32 a	47 a
15	70,000	52,818	11 ab	38 b	59 a	53,488	5 b	33 a	49 a
7.5	70,000	53,144	13 b	35 ab	55 a	55,979	2 a	35 a	46 a
			CV: 27.7	CV: 17.7	CV: 10.2		CV: 19.2	CV: 14.9	CV: 11.0

YIELD (pounds/acre)

Row spacing (inches)	Seeding rate (pls/ac)	Pinto beans: Plant population (plants/ac)	Pinto beans: Low disease pressure	Pinto beans: Intermediate disease pressure	Pinto beans: High disease pressure	Kidney beans: Plant population (plants/ac)	Kidney beans: Low disease pressure	Kidney beans: Intermediate disease pressure	Kidney beans: High disease pressure
30	70,000	50,894	3015 b	2596 a	1919 a	52,559	3015 ab	1799 b	1446 a
22.5	70,000	52,427	3022 b	2424 a	1836 a	50,606	3022 b	1878 b	1514 a
15	70,000	52,818	3398 a	2522 a	1876 a	53,488	3398 a	2309 a	1632 a
7.5	70,000	53,144	3305 a	2482 a	1738 a	55,979	3305 ab	2054 ab	1466 a
			CV: 7.4	CV: 8.1	CV: 8.0		CV: 6.4	CV: 10.6	CV: 13.1

Figure 1. Impact of row spacing on white mold severity and yield in pinto and kidney beans (light-red and dark-red). Data are from studies conducted in Carrington and Oakes, ND in 2019 and 2020 with no foliar fungicide, one or two fungicide applications, fallow ground, direct-seeded into winter rye terminated 10-14 days prior to planting, or direct-seeded into rye terminated 0-3 days after planting. *Within-column means followed by different letters are significantly different (P < 0.05; Tukey procedure).*

Planting pinto beans at 70,000 viable seeds per acre optimized agronomic performance under white mold pressure (Figures 2 and 3). Increasing seeding rate to either 90,000 or 120,000 viable seeds per acre had little impact on yield but was consistently associated with higher white mold disease pressure.

WHITE MOLD (% of canopy)

Row spacing (inches)	**Seeding rate** pure live (viable) seeds (pls/ac)	**Plant population** end-of-season (at maturity) (plants/ac)	**Low** disease pressure <20% of canopy (30-inch rows) **4 studies**	**Intermediate** disease pressure 20-40% of canopy (30-inch rows) **4 studies**	**High** disease pressure 40-60% of canopy (30-inch rows) **1 study**
30	120,000	96,439	11 a	36 ab	57 ab
30	70,000	48,536	8 a	22 a	58 ab
22.5	120,000	85,054	12 a	44 b	60 ab
22.5	70,000	42,646	8 a	28 ab	51 ab
15	120,000	90,750	10 a	42 b	75 b
15	70,000	48,972	8 a	35 ab	56 ab
7.5	120,000	115,454	10 a	36 ab	72 b
7.5	70,000	49,513	9 a	37 ab	46 a
			CV: 26.7	CV: 20.4	CV: 15.0

YIELD (pounds/acre)

Row spacing (inches)	**Seeding rate** (pls/ac)	**Plant population** (plants/ac)	**Low** disease pressure	**Intermediate** disease pressure	**High** disease pressure
30	120,000	96,439	3182 de	2846 ab	2403 a
30	70,000	48,536	3083 e	2937 a	2267 a
22.5	120,000	85,054	3614 bcd	2439 b	2318 a
22.5	70,000	42,646	3326 cde	2653 ab	2345 a
15	120,000	90,750	3867 ab	2849 ab	2041 a
15	70,000	48,972	3737 abc	2772 ab	2430 a
7.5	120,000	115,454	4148 a	2826 ab	1888 a
7.5	70,000	49,513	3937 ab	2643 ab	2173 a
			CV: 6.1	CV: 6.4	CV: 13.6

Figure 2. Impact of increasing seeding rate from 70,000 to 120,000 viable seeds/ac on white mold severity and yield in pinto beans. Data are from studies conducted in Carrington and Oakes, ND in 2019 with no foliar fungicide, one or two fungicide applications, fallow ground, direct-seeded into winter rye terminated 10-14 days prior to planting, or direct-seeded into rye terminated 0-3 days after planting. *Within-column means followed by different letters are significantly different (P < 0.05; Tukey procedure).*

Row spacing (inches)	Seeding rate, pure live (viable) seeds (pls/ac)	Pinto beans: Plant population, end-of-season (at maturity) (plants/ac)	Pinto beans: Low disease pressure: <20% of canopy (30-inch rows), 3 studies — WHITE MOLD (% of canopy)	Kidney beans: Plant population, end-of-season (at maturity) (plants/ac)	Kidney beans: Low disease pressure <20% of canopy (30-inch rows), 6 studies — WHITE MOLD (% of canopy)	Kidney beans: Intermediate to high disease pressure >20% of canopy (30-inch rows), 6 studies — WHITE MOLD (% of canopy)
30	90,000	76,935	8 a	60,875	4 ab	37 a
30	70,000	60,959	8 a	53,477	5 ab	36 a
22.5	90,000	84,820	10 a	59,822	6 b	37 a
22.5	70,000	70,218	8 a	51,680	4 ab	36 a
15	90,000	85,476	11 a	65,216	5 ab	35 a
15	70,000	65,817	7 a	53,974	5 ab	35 a
7.5	90,000	89,685	10 a	68,385	4 ab	37 a
7.5	70,000	68,483	8 a	57,744	2 a	36 a
			CV: 25.4		CV: 18.3	CV: 12.9

Row spacing (inches)	Seeding rate (pls/ac)	Pinto beans: Plant population (plants/ac)	Pinto beans: YIELD (lbs/acre)	Kidney beans: Plant population (plants/ac)	Kidney beans: Low disease pressure — YIELD (pounds/acre)	Kidney beans: Intermediate to high disease pressure — YIELD (pounds/acre)
30	90,000	76,935	3205 b	60,875	2150 bc	1916 b
30	70,000	60,959	3193 b	53,477	2152 bc	1920 b
22.5	90,000	84,820	3166 b	59,822	2225 abc	2112 ab
22.5	70,000	70,218	3142 b	51,680	2130 c	2060 ab
15	90,000	85,476	3356 ab	65,216	2501 a	2480 a
15	70,000	65,817	3494 a	53,974	2358 abc	2495 a
7.5	90,000	89,685	3301 ab	68,385	2443 ab	2189 ab
7.5	70,000	68,483	3265 ab	57,744	2318 abc	2182 ab
			CV: 4.1		CV: 7.0	CV: 11.2

Figure 3. Impact of increasing seeding rate from 70,000 to 90,000 viable seeds/ac on white mold severity and yield in pinto and kidney beans. Data are from studies conducted in Carrington, ND in 2020 (pinto beans) and Carrington and Oakes in 2019 and 2020 (kidney beans) with no foliar fungicide, one or two fungicide applications. *Within-column means followed by different letters are significantly different (P < 0.05; Tukey procedure).*

In kidney beans, seeding rate and row spacing had little or no impact on white mold severity, and yields were maximized in 15-inch rows irrespective of white mold pressure (Figure 3). Increasing seeding rate from 70,000 to 90,000 viable seeds per acre was associated with modest yield gains in 15-, 22.5-, and 30-inch rows when white mold pressure was low to moderate, but differences were not statistically significant. Increasing seeding rate had no impact on yield when white mold pressure was high (Fig. 3).

The research suggests that pinto bean seeding rate should be kept to 70,000 viable seeds/ac in fields where white mold is a concern. The optimal row spacing in pinto beans changes as disease pressure increases, with narrow (7.5 and 15-inch) rows optimal when white mold pressure is low to moderate and wide (30-inch) rows optimal when white mold pressure is high. The research also suggests that kidney bean agronomic performance is optimized in 15-inch rows irrespective of white mold pressure, and that increasing seeding rate from 70,000 to 90,000 viable seeds/ac confers no gain in yield when white mold pressure is high.

This research was conducted by M. Wunsch, Thomas Miorini, Jesse Hafner, Suanne Kallis and Xavier Klocke (NDSU Carrington Research Extension Center) and Kelly Cooper, Heidi Eslinger, and Seth Nelson (NDSU Oakes Irrigation Research Site).

Digital Applications for In-Field Scouting of Weeds and Pests

David Kramar

Introduction

The increase and continued expansion of noxious weeds in North Dakota represent a potential danger to the region's agricultural markets. North Dakota state law mandates that weeds identified or listed as noxious and troublesome must be controlled. Currently, North Dakota offers regular updates and recommendations for chemical control for a variety of troublesome and noxious weeds. In addition, information pertaining to biological control may be found by contacting the North Dakota Department of Agriculture or local staff of the United States Department of Agriculture - Animal and Plant Health Inspection Service. North Dakota Extension Weed Specialist and Assistant Professor Joe Ikley has revised a guide to noxious and troublesome weeds in North Dakota, under original authorship by Rodney G. Lym (Ikley, 2020). The recent expansion of palmer amaranth (*Amaranthus palmeri*) throughout the state is of concern given its propensity to develop herbicide resistance, prolific seed production, and rapid rate of growth. Moreover, palmer amaranth can contribute to decreased yields and gained its notoriety as it impacted the cotton industry in the southern United States. In North Dakota, palmer amaranth is a threat to the state's primary crops including soybean, sugarbeet, and corn. Perdue University estimates that palmer amaranth has the potential to reduce soybean yields by up to 79%.

Using both the Android and IOS Software Development Kits (SDK) and Geographic Information System (GIS) technology, this mobile application can be rapidly deployed and utilized via a traditional "smartphone" environment. Furthermore, the application is "scalable" meaning that it can evolve as new threats emerge. This relatively new technology offers an efficient and lightweight method for monitoring the presence and spread of noxious weeds within the state, and will contribute to ongoing mitigation efforts as required under state law. The application uses online web-mapping applications, the Android and IOS SDK's, and a lightweight mobile application to facilitate real-time collection and mapping. The current beta version allows the user to document one of four different noxious weeds and stores the GPS location, a photograph, the county within which it is located, and the relative prevalence. Further attributes will be defined based on discussions with Extension staff and weed specialists.

Mobile Application Development

The mobile application was developed using AppStudio Developer and ArcGIS AppStudio Player (for deployment), and is currently packaged as a deployable Android Package Kit (APK). The application was designed with ease-of-use in mind. The application was designed to record the data and push it to the web map/dashboard in just minutes. Should an individual find themselves in an area of limited cellular phone service, the application allows saving a draft of the incident until a cellular phone signal becomes available. Once "New" is clicked, the user will be brought to an informational page describing what information should be provided (Figure 1). To the extent possible, data is populated via drop-down menus and text boxes to facilitate rapid data collection (Figure 2). Step one is to select the Report Type. The location, obtained via the mobile device's integrated GPS chip, will appear on a map of the area on the user's device. Once the location has been identified and the user clicks "Next", they will have the opportunity to add up to six attachments. This would allow Extension agents, for example, to attach images of the leaves, petioles, and whole plant. After the attachments are made, the user can click "Next" and enter the attribute information from drop down menus, text boxes, and other form elements. Once the attributes have been collected the user clicks on the "Summary" button. This brings the user to the final screen where they may save the incident for later submission or submit the record.

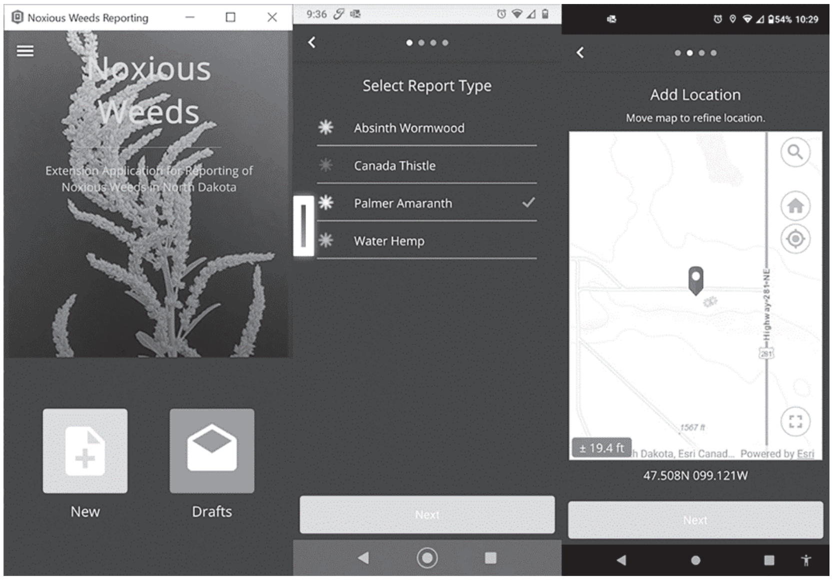

Figure 1: Initial report form screens and location screens. By selecting "New", the user can then select the report type. In this case, the selected type is palmer amaranth. The next screen allows the user to collect the GPS position using the GPS chip in their mobile device.

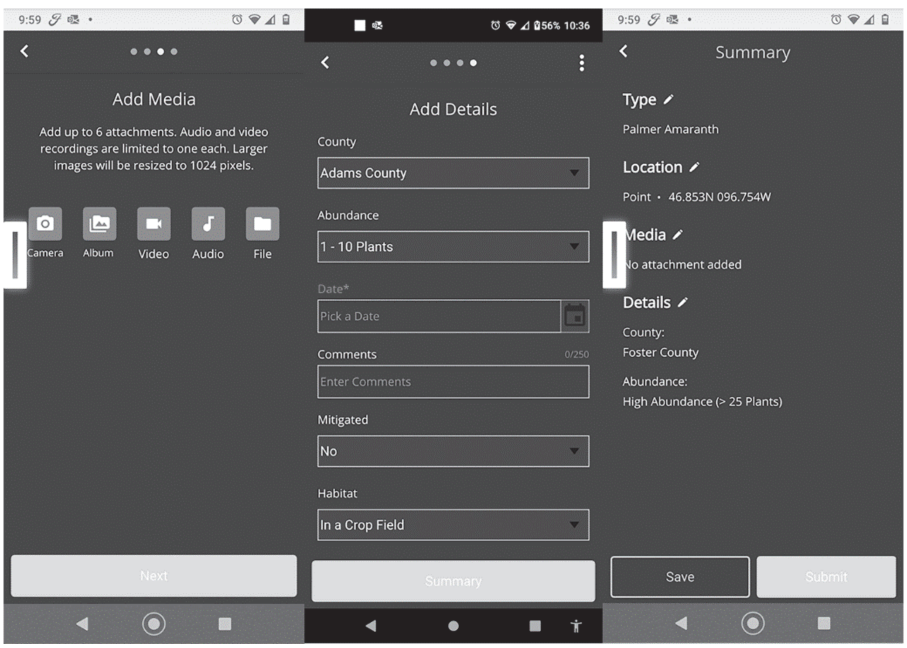

Figure 2: The "Add Media" screen allows the user to upload a picture. The "Add Details" screen prompts the user to enter relevant information pertaining to the location, abundance, mitigation status, and habitat. The "Summary" screen allows the user to save or immediately submit the records.

Summary

This application represents a "first" effort to develop technology that will aid in monitoring the spread of noxious weeds (and/or pests) in North Dakota. The real-time mapping capabilities provide a robust framework within which we can obtain actionable data for decision-making purposes.

The prototype uses a lightweight, but powerful platform that provides an easy-to-navigate application. Moreover, this platform may prove itself useful for other tasks such as Integrated Pest Management. As geospatial technologies become more integrated into our everyday lives, we will continue to see the development of novel applications to aid in our day-to-day tasks.

Variation in Soybean Variety Oil Content

Mike Ostlie

The soybean oil market is likely to receive a big boost in North Dakota over the next few years with one or more new crushing facilities opening. The new demand for soybean oil is driven by the commercial scale-up of renewable diesel. This is a separate product and market than the more familiar biodiesel. Any crop oil can be used in the production of renewable diesel, but at the moment, soybeans provide the most volume. As oil becomes a larger focus in marketing soybeans, it is important to take inventory of our current oil production potential by looking at genetic and environmental variability. This is especially important in markets such as renewable diesel which monitor the carbon cost of production versus per acre oil output.

At the Carrington Research Extension Center, we conduct 10 public soybean variety trials each year, consisting of public and private entries for GM and non-GM varieties. A wide range of data are collected from these trials each year, such as plant and pod height, maturity date, lodging, kernel weights, yield, test weight, and importantly here, seed oil and protein content. There were 238 soybean variety entries in 2021 (including duplicates tested at multiple environments) in our public trials, each replicated four times within environment. This season provided a good opportunity to evaluate oil content of varieties in good, average, and poor yielding environments. The environments included in this analysis are Carrington (dryland and irrigated), Oakes, Wishek, Dazey, and LaMoure.

Figure 1 shows the mean oil content values of each variety. Each bar is a compilation of variety performance at a single location. There was no clear correlation between variety yield and oil content, which is understandable as oil content is often not a trait used in breeding programs so its distribution is likely to be random. Across all trials the average oil was 19.75%. The difference between varieties within a single location ranged from 1.11% to 6.13%. Across all trials the lowest value was 15.23% and the maximum was 26.39%.

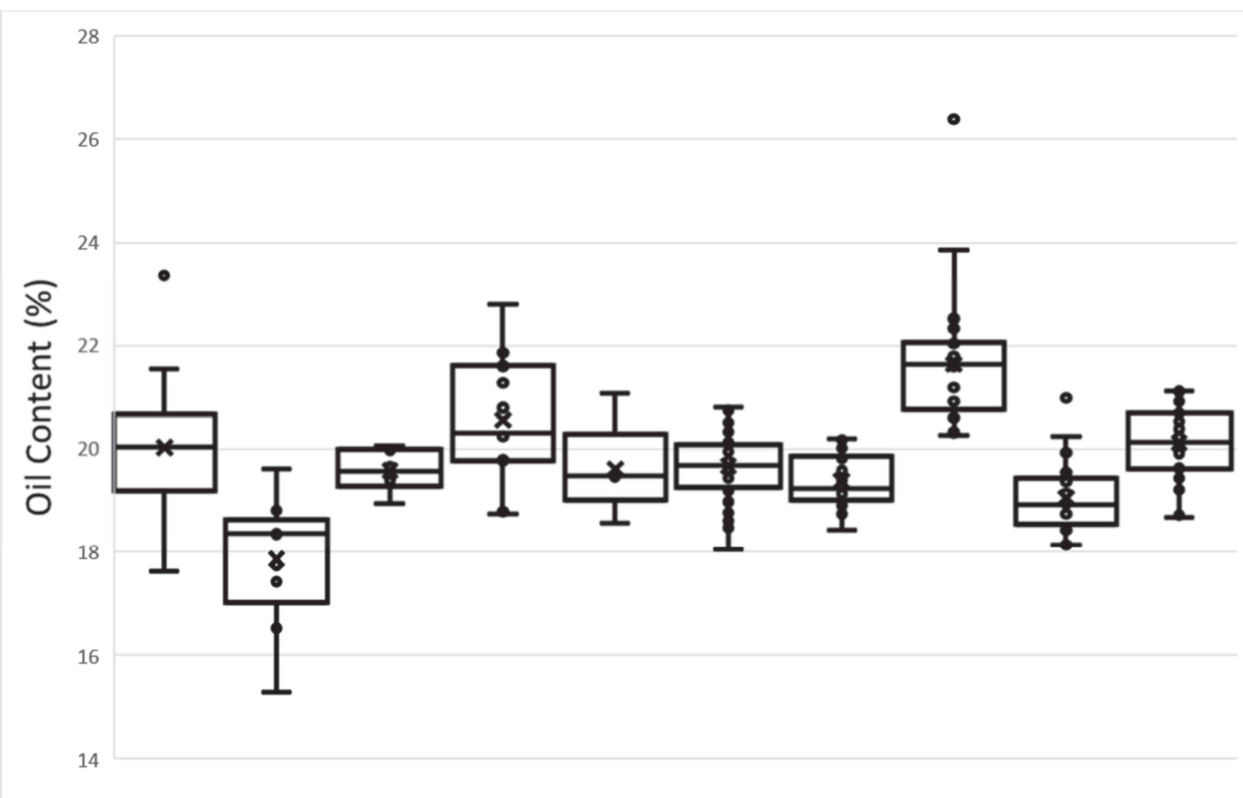

Figure 1. Oil content range in 10 variety trials across eastern North Dakota.

The second factor important to renewable diesel production is yield. Figure 2 shows the yield variability across the ten locations this season. Average yield of all trials was 36.7 bu/ac. The minimum yield was 9.9 bu/ac and the maximum was 72.7 bu/ac.

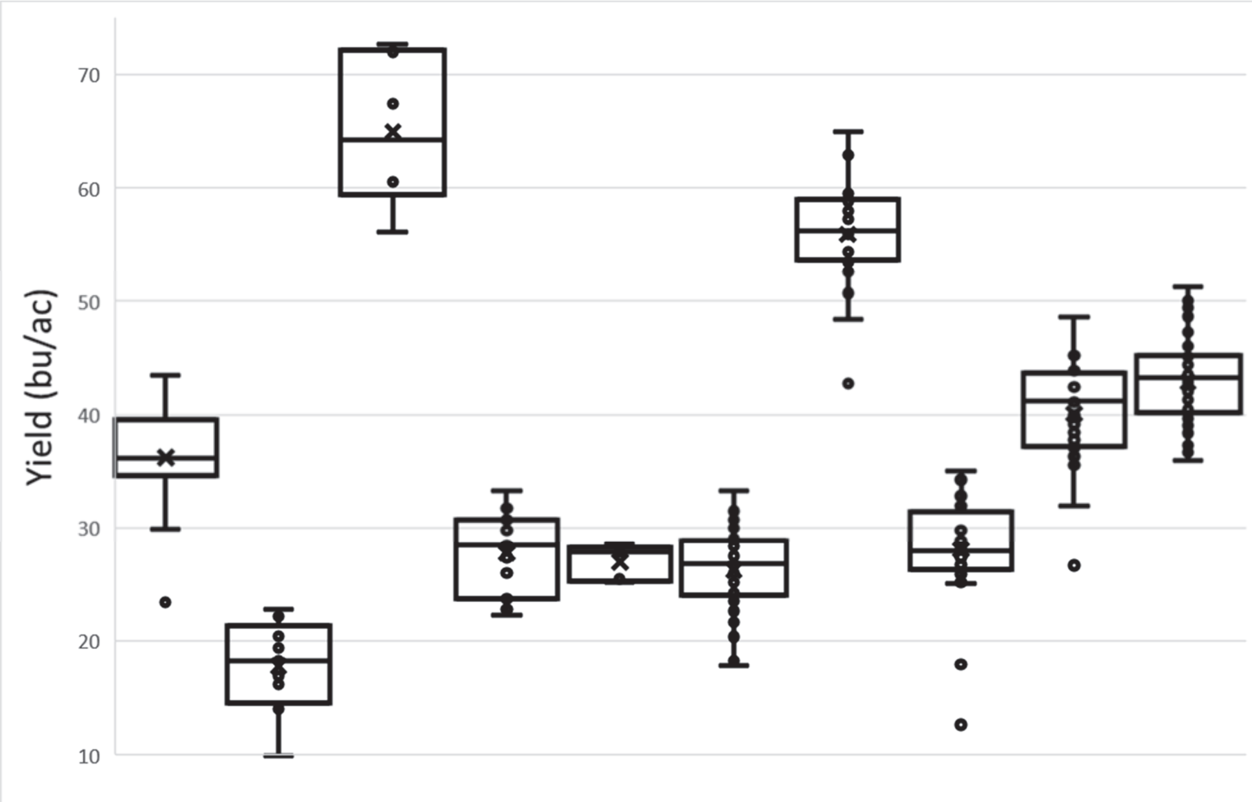

Figure 2. Yield range of 10 variety trials from across eastern North Dakota.

When considering average production of oil and yield (19.75% x 36.7 bu/ac) we end up with 2,202 lbs of soybeans producing 47.2 gal (7.6 lb/gal) of oil per acre for 2021. It is important that more work is devoted to understanding the limits of oil partitioning in soybean seed. To demonstrate, review the variables at specific sites. The site with the lowest average oil content had 17.85% oil content vs. the high of 21.63%. Using the average yield of 36.7 bu/ac production could be either 52 or 63 gal/ac (17.5% difference). Using the extreme oil values with average yield, production is 44 or 76 gal/ac. Right now, this difference is paid uniformly based only on bu/ac.

The ramifications of these differences are unknown at this time. At some point it is possible that premiums (or subsidies) will be paid for renewable diesel with the lowest carbon footprint. This is achieved through a combination of achieving higher yields and/or higher oil content. Currently, we are already able to demonstrate a 17.5% increase in efficiency of oil production without increasing yield. This increase is solely based on a combination of genotype and environment which can be improved further through monitoring of breeding material in current public and private programs.

Expanded Applications of GIS for CREC Field Management

David Kramar

Introduction

The role that Geographic Information System (GIS) plays in agriculture is rapidly expanding. The CREC has utilized GIS for many years as a way to maintain field maps of ongoing research trials. In 2021, there has been a concerted effort to streamline and organize the spatial data in a manner that would facilitate the continued use of GIS for mapping the locations of field trials and extend the capabilities so spatial data could be integrated into web mapping applications, data collection utilities, and flexibility in design for future needs. GIS can present challenges in terms of database design, data creation, data storage, and spatial analysis. In this article, the methods used to "clean up" the existing spatial data at the CREC, the migration of that data into a geodatabase structure, and the subsequent development of applications that can be used with basic mobile technologies are summarized. These applications of GIS offer increased flexibility to CREC staff to manage field trial information, sUAS flight log information, and a variety of other needs. In addition, management of these data offer the flexibility to evolve as the CREC spatial data needs change.

Methods

Projections and Topology

The standard projection for the CREC spatial data is based on the North American Datum of 1983 (NAD83) and utilizes the Universal Transverse Mercator (UTM) Zone 14 North projection (Table 1).

Table 1. Projection parameters for the spatial data at the CREC.

NAD 1983 UTM Zone 14N			
Projection	Transverse_Mercator	**Datum**	North American Datum 1983
False Easting	500,000 M East	**Spheroid**	GRS 1980
False Northing	0.0 M North	**Semimajor Axis**	6378137
Central Meridian	-99.0 West	**Semiminor Axis**	6356752.31
Latitude of Origin	0.0 North	**Flattening Ratio**	298.26
Linear Unit	Meters	**Angular Unit**	Degrees

The topology and geometry of the CREC field and trial data required significant modification to address errors in the spatial data. In addition to not adequately defining the projection of the data, the geometric errors included incorrect ring ordering, self-intersections, null geometry, and unclosed rings. Prior to moving these features into a geodatabase that supports the development of data schemas and web mapping applications, these geometric errors had to be identified and corrected. Once corrected the appropriate topology was generated which allowed for spatial query such as adjacency, proximity, and containment.

Data Schema, Geodatabase Development, and Web Map

The data schema utilized was based on information that the CREC has historically associated with each of the fields and trials. The geodatabase was developed to include both domains and coded values that would facilitate the data entry/collection aspects and minimize the potential for user-induced error into the system. The design of the geodatabase was also done in a manner that facilitates the migration to a representational state transfer (REST) endpoint that was used to develop the web-based mapping applications.

The map that was utilized for online applications was originally designed in ArcMap 10.8 and pushed, as a map package to a REST endpoint on NDSU's organizational ArcGIS Online account (Figure 1).

From here, the data could be accessed immediately from mobile devices and served as the base map for applications such as the CREC sUAS Flight Logger.

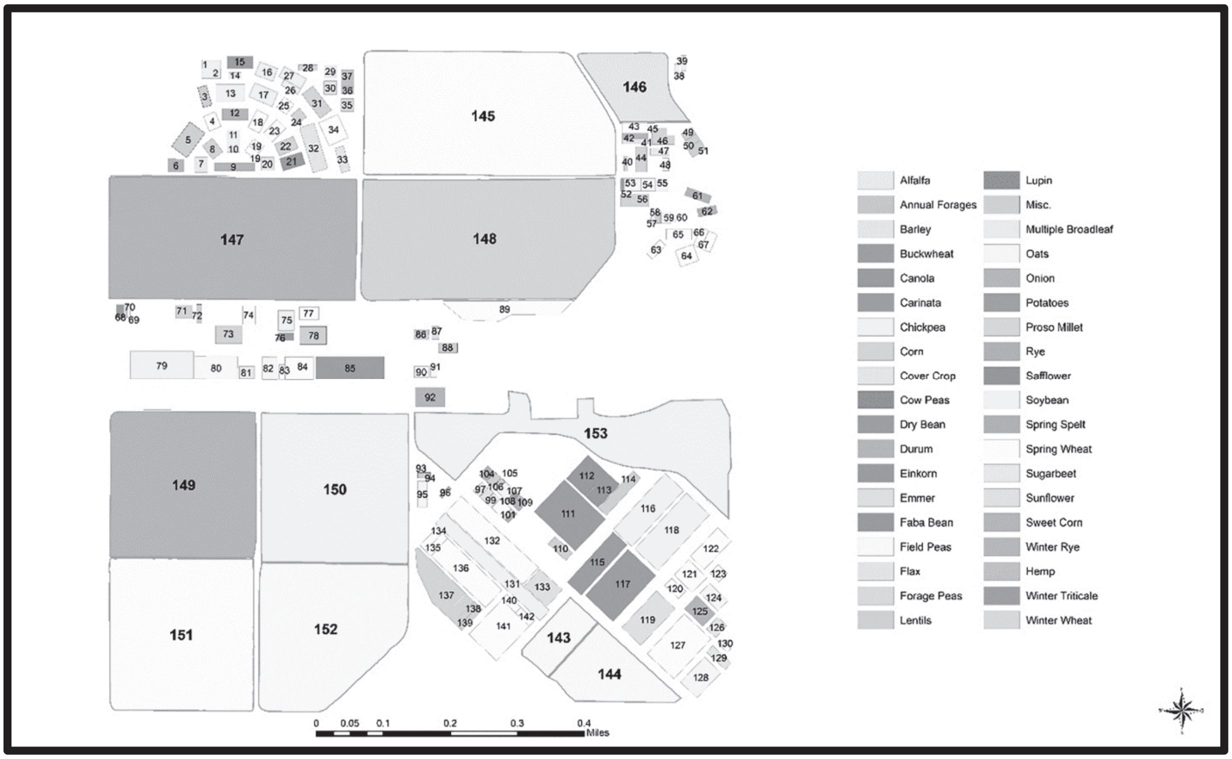

Figure 1. Example 2021 Research Trials at the CREC.

The application was developed using a template available in AGOL and allowed users to search based on the field or trial number, make measurements, and turn the legend on or off (Figure 2). The amount of information available is related to the amount of information that is associated with each of the fields/trials (Figure 3).

Figure2. The web-based implementation allows CREC staff to search for trials using the embedded attribute search functionality or identify trials by simply clicking on the polygon to retrieve the associated attributes. Additional tools for measurements and toggling the legend are also included.

Figure 3. After zooming in, attribute information can be readily obtained by clicking on the trial. Conversely, the search bar in the top left will simultaneously zoom to the plot while opening the attribute window.

Discussion

The current state and applied applications of GIS at the CREC is still evolving. The recent efforts to move the spatial data into a more flexible and sustainable format will allow the CREC to leverage the spatial analytical capabilities of GIS well beyond what has been done in the past. There is no question that geospatial technologies will continue to play a major role in precision agricultural applications, such as those being undertaken at the CREC. As our capabilities increase, the CREC will be able to map trial and plot corners on-the-fly using web-based data collection utilities, update existing treatment information, maintain a more manageable record of sUAS flights, and collect real-time data.

Experiences Using Distiller's By-products as a Fertilizer in Corn and Spring Wheat

Szilvia Yuja and Jasper Teboh

The by-products of corn ethanol production are rich in nutrients and can easily be sold as feed for cattle and swine. Because of the demand from livestock producers, wet distiller's grains (WDG) are usually priced too high for it to make economic sense to use as a fertilizer. But on occasion a crop producer that farms near an ethanol plant may find that WDG is available to him in great quantities at a very low price. Now what? How many nutrients are in the product? Would those nutrients be available to the plant? How does it compare to synthetic fertilizer? How much should be applied? Does it need to be worked in? Can it be stored? If you have these questions, then you're in luck. We have some answers.

Fertilizer trials with WDG began in 2015. Since then there have been 11 site-years of trials involving WDG in various treatment combinations applied to corn, wheat and soybean. Most WDG was sourced at Tharaldson ethanol near Casselton, ND, with the exception of one year from Dakota Spirit near Spiritwood, ND. A nutrient analysis was completed on the product to determine application rates. Analysis is always a good idea because the nutrient content not only varies from ethanol plant to ethanol plant, but from batch to batch. In five years of samples, nitrogen ranged from 32 to 52 lbs per ton of fresh WDG, phosphate from 14 to 43 lbs and potash from 11 to 31 lbs. This is by no means the full range of what the NPK contents can be. WDG contains other nutrients as well (Table 1) that can be useful for the plants.

Table 1. WDG nutrient content summary based on 5 years of samples.

	lowest value	highest value	average	Nutrients per ton of wet matter (lbs)
moisture (%)	50	67.7	61.54	
Nutrient (dry basis)				
nitrogen %	3.3	5.6	4.8	37
ammonium nitrogen %	0.022	0.316	0.127	1
nitrate nitrogen %	0.003	0.013	0.007	0.05
inorganic nitrogen %	0.026	0.316	0.129	1
organic nitrogen %	3.3	5.0	4.3	33
phosphate %	2.2	5.7	3.3	25
potash %	1.7	4.1	2.4	18
sulfur %	0.68	1.2	0.93	7.2
sodium %	0.35	0.77	0.55	4
calcium %	0.04	0.56	0.15	1.12
magnesium %	0.55	1.2	0.74	5.7
zinc (ppm)	59	119	79	0.6
iron (ppm)	92	270	153	1.17
manganese (ppm)	19	41	29	0.22
copper (ppm)	4	8.5	6	0.05

Nutrient availability

How available are the phosphorus and nitrogen nutrients? In a corn study where WDG was used as a nitrogen source, it was compared to urea and a 50:50 mix of WDG and urea at different rates (Figure 1). Note a 100% optimal rate was only 45 lbs N due to high residual nitrogen. The yield differences were not significant, but it seems that the 50:50 mix of WDG and urea had the highest yield at two of the N rates and tied for the top with pure WDG at the highest N rate.

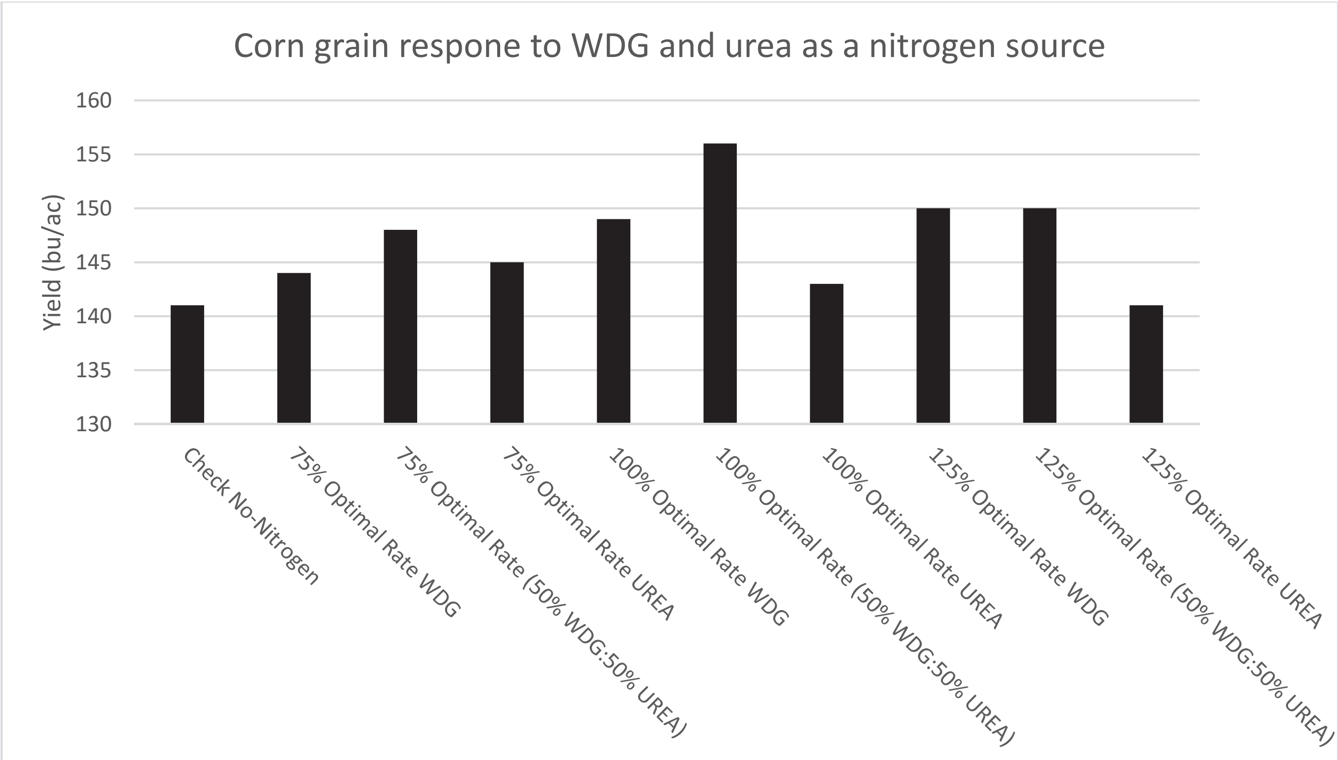

Figure 1. Corn grain yield response to WDG and urea as a nitrogen source in 2015.

There was a series of wheat studies in which WDG was applied based on phosphorus rates and was compared to triple superphosphate (TSP). In these studies, the nitrogen applied was equalized for all the treatments to receive the amount supplied by the high rate of WDG, which, as discussed earlier, was different each year. The check also received nitrogen. Nitrogen was supplemented using urea. For this reason, these trials provide an excellent opportunity to compare WDG to synthetic fertilizers. The highest rate of WDG, applied at the 80 lb P_2O_5 rate in 2016, 2017 and 2018, can be compared to the 80 lb TSP rates, since in these treatments nitrogen either comes from WDG (WDG-80) or from urea (TSP-80). In all 3 years we can see that the WDG treatment yielded higher than the TSP treatment. This was significant only in 2016, but the results suggest that nitrogen from WDG was at the very least no less available as it was from urea. In 2019, only the TSP-40 treatment and the WDG-40 treatment received the same level of nitrogen. These two treatments yielded roughly the same again suggesting that there was no problem with the nitrogen availability in the WDG treatment. Those same graphs show that WDG did similarly well as a source of phosphorus, as the yields coming from the same applied phosphorus levels were comparable or slightly better for WDG than for TSP. Grain protein levels did not respond differently in any significant or consistent way to WDG compared to synthetic fertilizers in these trials.

In summary, even though nitrogen and phosphorus are held in organic matter in WDG, they seem to become available during the subsequent growing season, most likely due a very low carbon to nitrogen ratio of WDG (9-10:1). As a comparison, raw beef feedlot manure is around 10-20 to 1.

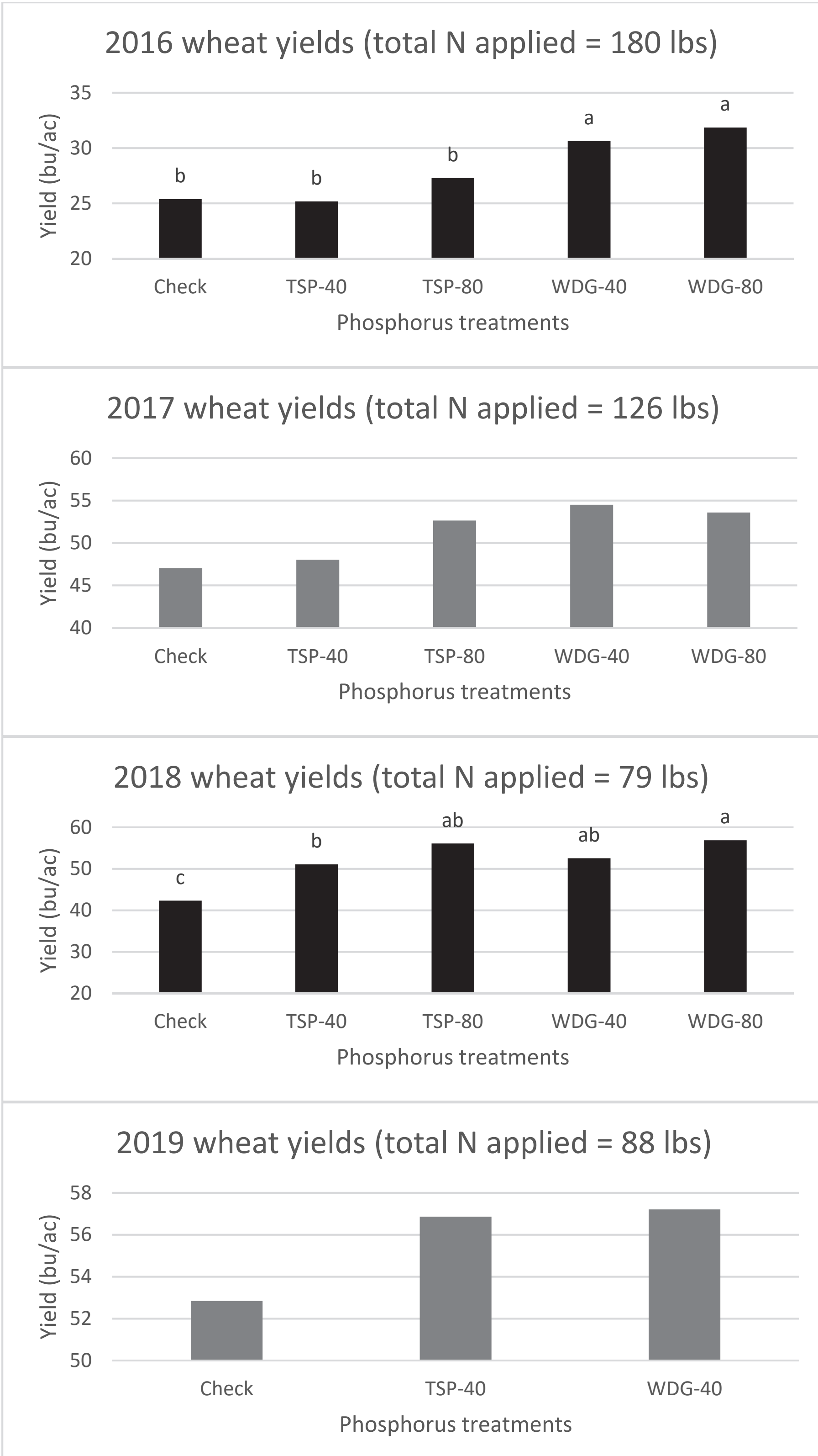

Figure 2. Four years of wheat yield response to phosphorus rates applied as triple superphosphate (TSP) or wet distiller's grain (WDG) at an equal level of nitrogen supplied to all treatments, including the check, as urea or as a part of WDG. The highest level of WDG in each graph is responsible for supplying the entire N rate to the treatment, whereas the lower rate WDG is supplemented with urea. *Separate letters represent differences at the alpha = 0.05 level.*

Incorporation

Do WDGs need to be worked in? In the 2016 and 2017, trials half of the area had WDG worked in using a cultivator and in the other half it was left on the surface. Figure 3 shows the results of that experiment. Yield was not significantly affected by incorporation in either of those years. In 2016 the average yield was slightly lower after incorporation and in 2017 it was slightly higher. From this limited amount of data, there is no clear benefit to incorporating WDG.

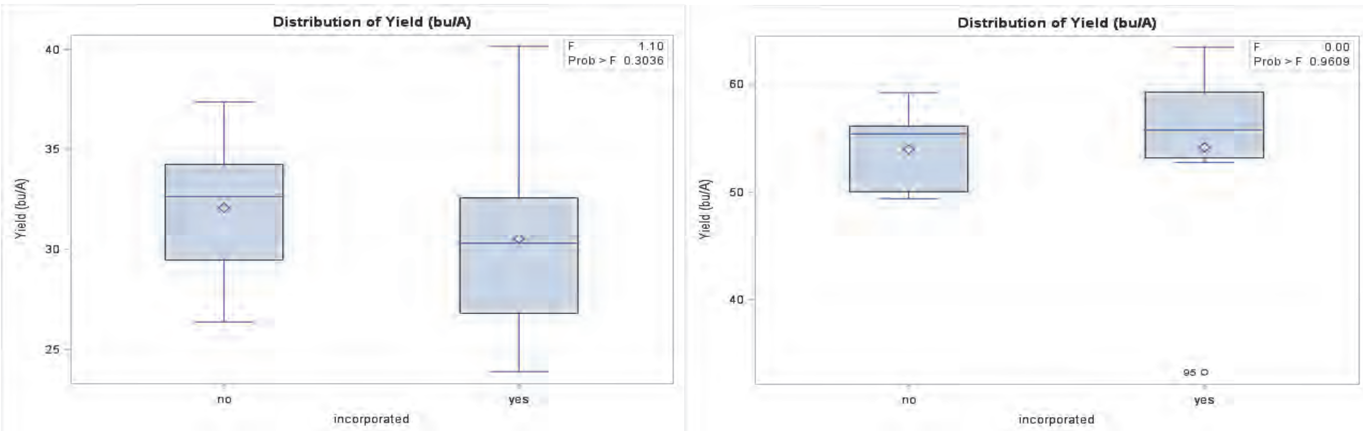

Figure 3. Spring wheat yield differences by WDG incorporation in 2016, left, and 2017, right.

Storage

No experiments on different storage conditions have been completed so there is no replicated data.

The WDG for the trials was procured fresh from the ethanol factory in early spring, then stored in a grain tote in an unheated barn until application time before planting. Leftover quantities were kept, but once temperatures rose above the 50s, it started to degrade with mold and a bad smell. This is anecdotal evidence and controlled experiments should be completed to determine the best storage conditions and limitation.

Impact of Soil K Test and Smectite/Illite Clay Ratio on K Fertilization

Jasper M. Teboh, Szilvia Yuja, Ezra Aberle, and Mike Ostlie

Introduction

Severe potassium (K) deficiency symptoms were seen on corn plants on some dryland research fields and in some growing seasons at the NDSU Carrington Research Extension Center (CREC). Soil tests show these fields have medium to high levels of K (≥ 130 ppm). When deficiencies occur and are not corrected, or are corrected by topdressing the crop with K fertilizer, the deficiencies often gradually disappear as K becomes available. It is not known how yields are impacted by K deficiency or how much yield loss is prevented from corrective measures. K fertilizer is not normally applied to the CREC research fields because response has been weak in the past, probably due to levels of K, or the clay mineralogy. Franzen et al. (2018) shows reduced likelihood of crop response to K when the smectite/illite clay ratio of the soil is < 3.5 and soil K is medium to high.

Objectives

- Determine whether starter and topdress K fertilization will impact corn response.
- Determine whether the clay mineralogy of three CREC research sites would be different and the response of corn to K fertilization.

Methods
Three corn trials were established on three separate fields at the CREC to assess corn response to K fertilization treatments. Two trials were on dryland (Field 6 and Q5) and one under irrigation (Field 4). A portion of composite soil samples from each site was analyzed to determine K levels, and the other portion for the smectite/illite clay ratio. The seven K treatments were:

- Four pre-plant K rates at 0 (control), 50, 100, 150 lbs K_2O/ac
- Three one-time topdress treatments of 40 lbs K at either V6, V10, or VT (tasseling).

Leaf K concentration was determined from the youngest fully collared leaves at V10 and VT before topdressing with muriate of potash (MOP).

Results and Discussion
Soil K level was high for all sites and the smectite/illite ratio was below 3.5 at each site (Table 1). Leaf K concentration increased significantly at higher K rates at Field 4 and Q5 but not at Field 6 (Figure 1). Grain yields and quality were not impacted. The significant K leaf uptake with applied rates of K with no impact on grain yields can be described as luxury consumption of K by the crop. Midseason observation of the crop leaves had shown no evidence of K deficiency, which explains why K applied by topdressing had no effect on corn response. Even though there was no obvious reason why differences in K uptake were not significant at Field 6, it is probable that the larger biomass of the crop at field 6 contributed in diluting the leaf K to lower concentration levels.

Table 1. Soil test K and smectite/illite ratio by site and yields by K rates and site.

Site	Soil K	Smectite/Illite ratio	K Rates (lbs/ac) 0	50	100	150	Analysis of variance
	ppm		------------ Yield (bu/ac)			--------------	----*P*---
Field 4	149	2.83	172	159	177	159	NS
Field 6	205	2.13	178	169	189	161	NS
Q5	207	1.11	175	161	153	168	NS

NS - mean yield differences were not significant between treatments at each site.

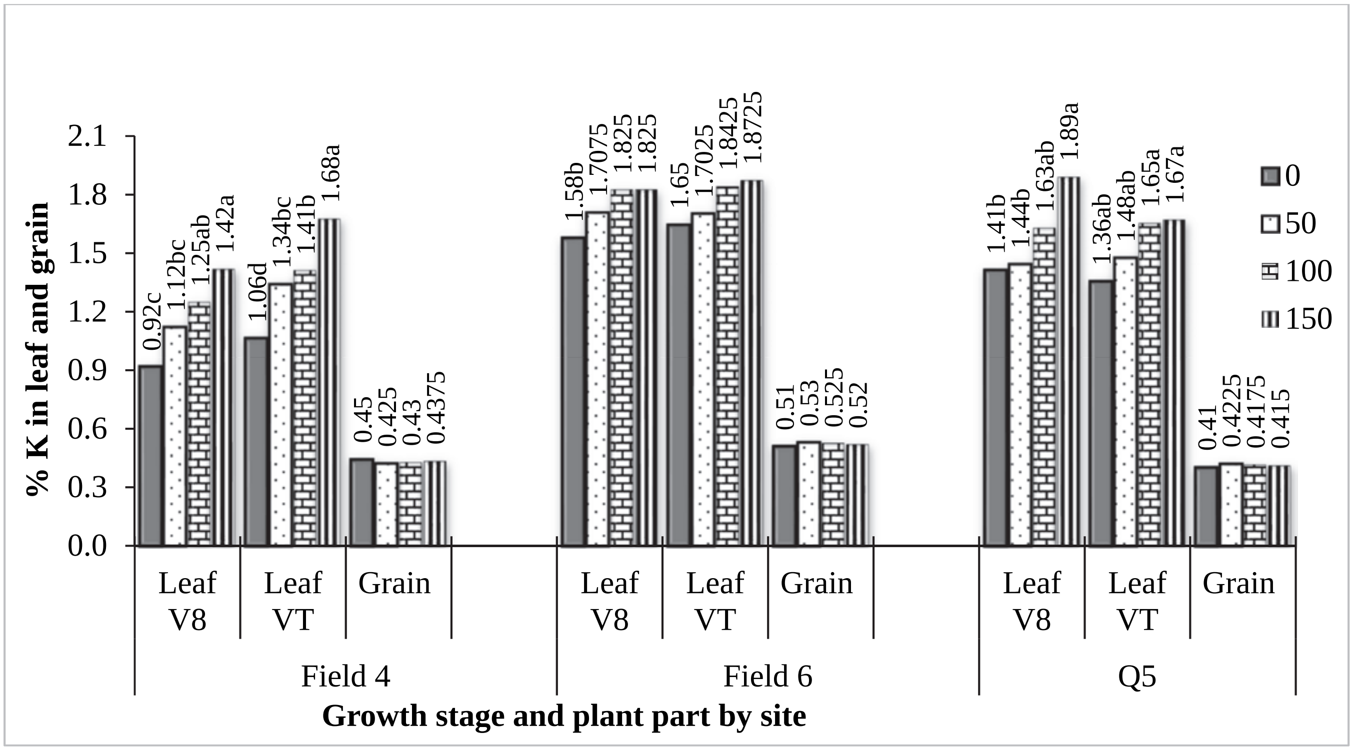

Fig 1. Effect of starter K fertilizer on corn leaf K concentration at V10 and VT, and grain K at three sites.

Along with high soil K, the lack of K impact on yields may also be explained by the smectite/illite ratio being less than 3.5 at all three sites. Based on the NDSU revised K fertilizer recommendation for crops in North Dakota, corn is unlikely to produce a positive yield response to K for soils having smectite/illite ratio less than 3.5, and soil available K levels ≥ 150 ppm (Franzen et al., 2018). Because these soils have relatively high illite clays, which contribute K when the soil is dry or wet while smectite clay supplies K mainly when the soil is wet, K application would not be recommended at current levels of soil test K. We believe that unless soil K is <135 ppm, K fertilization will likely not impact yields, unless applied to correct observed K deficiencies that result from drought-induced low K availability and uptake.

Conclusion

On the basis of clay mineralogy and K soil analysis, application of K fertilizer to corn is unlikely to result in yield benefits at any of the three sites used in this study. More studies are needed to quantify the yield impact of K application as a corrective measure for deficient crops.

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Update on CREC Corn Starter and Foliar Fertilizer Research: Phosphorus and Zinc

Greg Endres

NDSU recommends starter phosphorus (P) fertilizer for corn, regardless of P soil level. Starter fertilizer application is defined as either placing in-furrow (IF) or within 2 inches of corn seed during planting, with typical rates of 10-34-0 at 3 gpa. P starter fertilizer provides the potential to increase early season plant growth by increasing nutrient uptake, and ultimately increase grain yield. Starter fertilizer will not satisfy total P needs of corn with soils testing less than medium for P (<8 ppm; Olsen test), thus supplemental P fertilizer (broadcast or deep-band application) would be recommended. Corn is expected to respond to zinc (Zn) fertilizer if soil levels are below 1 ppm. Zn may be applied as preplant broadcast, starter or foliar. P and Zn fertilizer rate recommendations are in the NDSU Extension publication ‘Soil Fertility Recommendations for Corn’.

The CREC began a series of corn field trials in 2007 to document response to starter P fertilizer, primarily using 10-34-0 with various application methods and rates on soils generally testing medium or less for P. Averaged across 8 site-years, IF or 2-inch band applied 10-34-0 at 2.5 to 6 gpa had similar early season plant stands between P application methods, and increased grain yield 4-5% compared to the untreated check. Data and details of research during 2007-2016 are summarized in the NDSU Extension publication ‘Corn Response to P Starter Fertilizer in ND’.

In 2016, the research focus transitioned to tests with Zn, preplant incorporated (PPI), and specialty fertilizers compared to IF-applied 10-34-0 at 2.5-3 gpa in soil with P levels at ≤8 ppm and Zn at ≤0.65 ppm. The following is a summary of corn grain yield response with various fertilizer treatment comparisons using multi-year means through 2021:

- Corn response was similar between IF 10-34-0 and <u>surface-applied band 10-34-0</u> (4 site-years). Rain totaling ≥0.3 inches for incorporation of surface-applied fertilizer was delayed ≥5 days after application among years.
- IF 10-34-0 plus <u>Zn chelate</u> (0.25 gpa) was 4% greater than sole 10-34-0 or the untreated check (5 site-years).
- IF 10-34-0 plus Zn chelate (0.25 gpa) was 3% greater than 10-34-0 followed by <u>foliar-applied Zn</u> chelate (Applied at V4-6 growth stages; 4 site-years).
- PPI <u>MESZ</u> (MicroEssentials SZ [12-40-0-10S-1Zn]; Mosaic) was 3% greater than PPI triple super phosphate plus ammonium sulfate (S) plus ZnS, with both treatments containing similar amounts of P, S and Zn on a plant food basis, and followed by IF 10-34-0 (3 site-years).
- IF 10-34-0 plus Zn chelate (0.25 gpa) was 3% greater than IF <u>RiseR</u> (7-17-3-0.95Zn; Loveland Products) at 2.5 gpa (3 site-years).

Corn plant population was similar among all treatments in each trial conducted during 2016-20. However, in the 2021 trial, plant stand was generally reduced (11-16%) with IF 10-34-0 compared to the untreated check, due to dry topsoil during plant establishment. IF starter fertilizer sources and rates need to be considered during adverse soil conditions such as in 2021.

Optimizing Fungicide Application Interval Relative to Soybean Maturity for Improved White Mold Management in Soybeans

Michael Wunsch

When making two successive fungicide applications, the standard recommendation is to make applications 10 to 14 days apart if weather remains favorable for the target disease. However, the recommendation of applying fungicides 10 to 14 days apart when targeting white mold in soybeans is not based on empirical data and differs from standard practice in other regions of the world. In Brazil, where white mold is a serious constraint for soybean production and fungicides are widely utilized for white mold management, fungicides targeting white mold are applied twice sequentially on a target 7- to 10-day interval.

In 2019 and 2020, the plant pathology program at the Carrington Research Extension Center, in conjunction with the agronomists at the Oakes Irrigation Research Site, evaluated the impact of the interval (7 to 14 days) between sequential fungicide applications targeting white mold in soybeans. In 2019, testing was conducted on 0.1, 0.5, and 0.9-maturity varieties in Oakes and Carrington. On each variety, one versus two applications of Topsin (20 fl oz/ac) and one versus two applications of Endura (5.5 oz/ac) were tested, with sequential applications made 7, 10, or 14 days apart. In 2020, testing was conducted on 00.9, 0.6, and 0.9-maturity varieties in Carrington and on 0.6, 0.9 and 1.1-maturity varieties in Oakes. On each variety, one versus two applications of Endura (5.5 oz/ac) or a single application of Topsin (40 fl oz/ac) or Topsin (40 fl oz/ac) followed by Endura (5.5 oz/ac) were tested, with sequential applications made 7, 10, 12, or 14 days apart. The first fungicide application was made at the early to full R2 growth stage. Plots consisted of either three rows, each 21 inches apart, or four rows, each 14 inches apart. Plot length at seeding was 25 feet long, with the interior approx. 19 feet harvested for yield. All studies were conducted with eight experimental replicates. Overhead irrigation was applied as needed to create conditions favorable for white mold. White mold was assessed shortly before or at maturity, with a quarter to half of the plants individually assessed for disease in each plot. White mold pressure was moderate (11% of the canopy diseased in the non-treated control) in the 0.9-maturity variety evaluated in Carrington in 2020, and white mold pressure was high (>25% of the canopy diseased in the non-treated control) in 0.6 and 0.9-maturity varieties evaluated in Carrington in 2021 and in all three varieties assessed in Oakes in 2021. In these studies, a second fungicide application improved white mold management and soybean yield, and the optimal interval between applications could be evaluated. In all other varieties assessed, white mold pressure was low (1 to 4% of the canopy diseased in the non-treated control), and a second fungicide application conferred no improvements in disease control or soybean yield.

The optimal number of days between fungicide applications was contingent on soybean maturity (Figure 1). In the 0.6-maturity variety, 7 days between applications optimized fungicide performance. In 0.9-maturity varieties, 7 days between applications optimized fungicide performance, but the difference between 7 and 10 days was small. In the 1.1-maturity variety, 14 days between applications optimized fungicide performance.

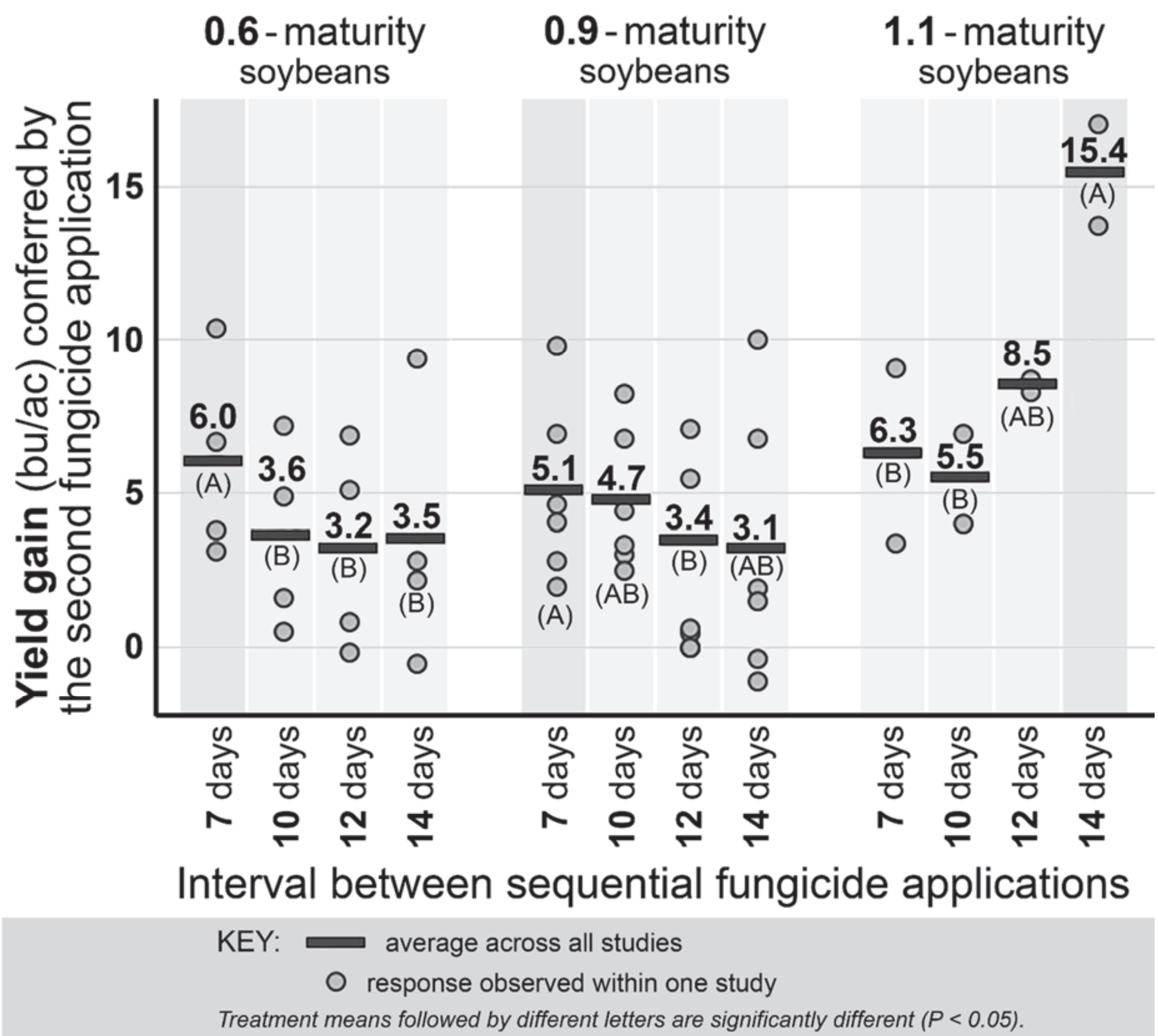


Figure 1. Impact of the interval between sequential fungicide applications (7, 10, 12 or 14 days) on the yield gain conferred by a second fungicide application in 0.6, 0.9 and 1.1-maturity soybeans under moderate to high white mold pressure; Carrington and Oakes, ND (2020-21).

The results need to be confirmed with additional testing before final recommendations can be developed, but they suggest that the optimal interval between successive fungicide applications targeting white mold is determined by the length of the soybean bloom period. Nearly all white mold infections in soybeans occur during bloom. Because the length of the bloom period increases with soybean maturity, longer-maturity soybeans are susceptible to white mold for a longer period of time. In the 0.6-maturity soybeans, making applications 7 days apart was sufficient to protect soybeans through the end of full bloom, and applying on a 7-day interval maximized the fungicide residual levels at the critical R3 growth stage when the soybean canopy carries abundant dead blossoms. In the 1.1-maturity soybeans, making applications 14 days apart was necessary to protect soybeans through the end of bloom.

This research was conducted by M. Wunsch, Thomas Miorini, Jesse Hafner, Suanne Kallis and Xavier Klocke (NDSU Carrington Research Extension Center) and Kelly Cooper, Heidi Eslinger, and Seth Nelson (NDSU Oakes Irrigation Research Site).

Effects of Enhanced Efficiency Nitrogen Fertilizers on Corn and Wheat Grown Under Irrigation

Jasper M. Teboh, Szilvia Yuja, and Mike Ostlie

Introduction

Numerous nitrogen (N) fertilizers are advertised and sold to farmers annually as enhanced efficiency N fertilizers (EENFs) that are supposed to protect N loss in soil by delaying or controlling N release from the fertilizer. Only a few of them are effective. Because EENFs cost substantially more than conventional fertilizers, the amount of N prevented from loss compared to a conventional N fertilizer must also be significant enough to enhance grain yield or quality to justify the cost. Field trials were conducted to compare yield response to EENFs at various N rates.

Objectives

- Assess the impact of three commercial polymer-coated fertilizers on yield of corn and wheat
- Compare corn yield impact of four formulations of newly developed soy-based polymer coated slow-release N fertilizers to commercially available enhanced efficiency fertilizers.

Methods

Three trials were conducted under irrigation: two corn trials at Oakes, and a wheat trial at Carrington. A dryland corn trial was lost to drought. All treatments were applied on the surface without incorporation. Treatments for the first corn trial (urease inhibitor trial) at Oakes consisted of urea and three polymer-coated N fertilizers (Agrotain, ANVOL, SuperU), which contain the NBPT urease inhibitor. Each N source was applied at 80, 120, and 160 lbs N/ac. Soil test N was 33 lbs/ac.

Treatments for the second corn trial (slow release N trial) at Oakes were urea, ESN, SuperU, and four soy-based, polymer-coated N fertilizer formulations (RVix1, RVix2, RVix3, and RVix4) applied at 107 lbs N. Urea was also applied at 53 lbs, 162 lbs, and a control (0 lbs N). Soil test N was 47 lbs/ac. Treatments for the wheat at Carrington were Agrotain, ANVOL, SuperU, and urea applied at 60, 90, 120 lbs N. Soil test N was 43 lbs/ac.

Results and Discussion

At Oakes, N sources had similar impact on yields for both corn trials. This was probably because N fertilization had no significant effects on yields. Important N contribution may have come from other sources like soil residual N, soil organic matter mineralization, or irrigation water (Table 1). For the slow-release corn trial that included a control treatment (0 lbs N) and N at 53 lbs, even though yields increased at higher N rates (107 and 162 lbs) neither the grain yield nor protein differences were significant. Meanwhile, for the urease inhibitor trial, grain protein and test weight improved significantly at higher N rates. Assessment of crop vigor at V8 to V10 was done by measuring the crop canopy reflectance with a sensor that produced NDVI (Normalized Difference Vegetation Index) values. These values showed differences between treatments were not significant.

Table 1. Effects of N rates and N sources on corn grain yield and quality (Oakes).

N Rate	Yield	Protein	TWT	Starch	NDVI
lbs/ac	bu/ac	%	lb/bu	%	
80	272	7.22b	57.1b	72.7a	0.713
120	281	7.62ab	57.9ab	72.4ab	0.700
160	277	7.94a	58.0a	72.2b	0.675
Mean	277	7.59	57.7	72.4	0.696
Urea	268	7.56	57.7	72.4	0.695
Agrotain	283	7.64	57.9	72.4	0.701
Anvol	276	7.57	58.0	72.4	0.689
SuperU	279	7.62	57.9	72.5	0.700
Mean	279	7.59	57.7	72.4	0.696
Analysis of Variance	---------------------------***P-Values*** ----------------------				
N Rates	0.2522	0.0018	*0.0470*	0.0251	<0.0001
N Sources	0.1101	0.9751	*0.4483*	0.94444	0.531
N Rates x N Sources	0.2474	0.1362	*0.2078*	0.1382	0.594

Means within a column with similar letters are not significantly different.

Response of wheat yields to N rates and sources was also weak at Carrington. Besides grain protein, which improved significantly with higher rates of N, neither test weight, kernel weight, nor NDVI were impacted by rates or sources of N (Table 2). Failure to observe significant impact of applying N fertilizer to both corn and wheat implies that the effects of the different N sources could not be differentiated.

Table 2. Effects of N rates and N sources on wheat grain yield and quality.

N Rate	Yield	Protein	TWT	KWT	NDVI
lbs/ac	bu/ac	%	lb/bu	g/250 seeds	
60	68	15.39b	64.2	9.15	0.783
90	67	15.94a	64.0	8.91	0.792
120	68	16.18a	64.0	8.91	0.785
Mean	67	15.84	64.1	8.99	0.786
Urea	68	15.81	64.1	8.99	0.787
Anvol	69	15.78	63.8	9.06	0.788
SuperU	66	15.78	64.1	8.92	0.784
Mean	67	15.79	64.0	8.99	0.786
Analysis of Variance	---------------------***P-Values***----------------------				
N Rates	0.8251	<.0001	0.0630	0.0978	0.6042
N Sources	0.5753	0.6452	0.0731	0.5305	0.8930
N Rates x N Sources	0.5610	0.571	0.9034	0.1775	0.9815

Means within a column with similar letters are not significantly different.

Conclusion
Yields were not significantly improved by applying EENFs over urea. In order for EENFs to minimize N loss and produce significant yield differences from urea, the fertilizers must be placed under conditions where N loss is very high. The farmer's decision to pay for more expensive EENFs should be weighed against a number of factors including fertilizer costs, making sure to spend on these EENFs only if prevailing conditions are likely to cause significant N loss.

Partial funding for this project was provided by the North Dakota Corn Utilization Council and Koch Agronomic Services.

Impact of Sulfur and Nitrogen as Starter and Topdress Applications on Canola

Jasper M. Teboh, Szilvia Yuja, and Mike Ostlie

Introduction
Nitrogen (N) and sulfur (S) fertilizers are vital in canola production. Split application of N and use of enhanced efficiency N fertilizers (EENFs) are some of the strategies farmers use in an attempt to enhance efficient nutrient uptake and use by plants. Even though EENFs may reduce N loss following mid-season topdress application of urea N, the impact of applying EENFs has not been consistent. While it is a common practice to apply S fertilizer all at planting, previous European studies have proposed application of S at bolting to maximize canola uptake and use efficiency.

Objectives
- Quantify yield differences between single versus split N fertilizer application for canola.
- Assess the impact of topdressing canola with enhanced efficiency fertilizers (Agrotain and SuperU) versus conventional (unprotected) urea.
- Assess yield differences between 10 and 20 lbs S, and S applied as starter versus as topdress.

Methods
The trial was conducted under irrigation at the Carrington REC. The soil N test was 47 lb/ac. The rates of N reported here are for soil N + actual added N fertilizer. For example, 150 lbs N means 47 lbs soil N + 103 lbs added N, and 120 lbs N rate is 47 lbs soil N + 73 lbs added N. Treatments 14 to 16 received 63 lbs N at planting and 40 lbs N as topdress.

Treatments are as follows:
Treatments 1 through 9 received all the fertilizer as starter.

1. 0 lbs N, 0 S lbs
2. 0 lbs N, 20 lbs S
3. 150 lbs N, 0 lbs S
4. 90 lbs N, 10 lbs S
5. 90 lbs N, 20 lbs S
6. 120 lbs N, 10 lbs S
7. 120 lbs N, 20 lbs S
8. 150 lbs N, 10 lbs S
9. 150 lbs N, 20 lbs S

Treatments 10 through 13 received only N as a starter. S was applied at bolting.

10. 120 lbs N, 0 lbs S starter, 10 lbs S topdress
11. 120 lbs N, 0 lbs S starter, 20 lbs S topdress
12. 150 lbs N, 0 lbs S starter, 10 lbs S topdress
13. 150 lbs N, 0 lbs S starter, 20 lbs S topdress

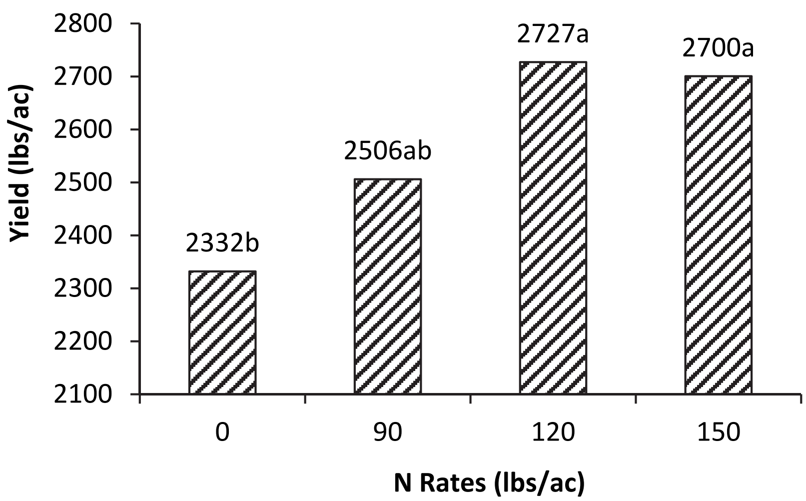
Treatments 14 through 16: N rate (150 lbs) split applied with 40 lbs N at bolting (20 lbs S applied preplant).

14. 110 lbs N starter, 40 lbs N topdress with Urea
15. 110 lbs N starter, 40 lbs N topdress with Agrotain
16. 110 lbs N starter, 40 lbs N topdress with SuperU

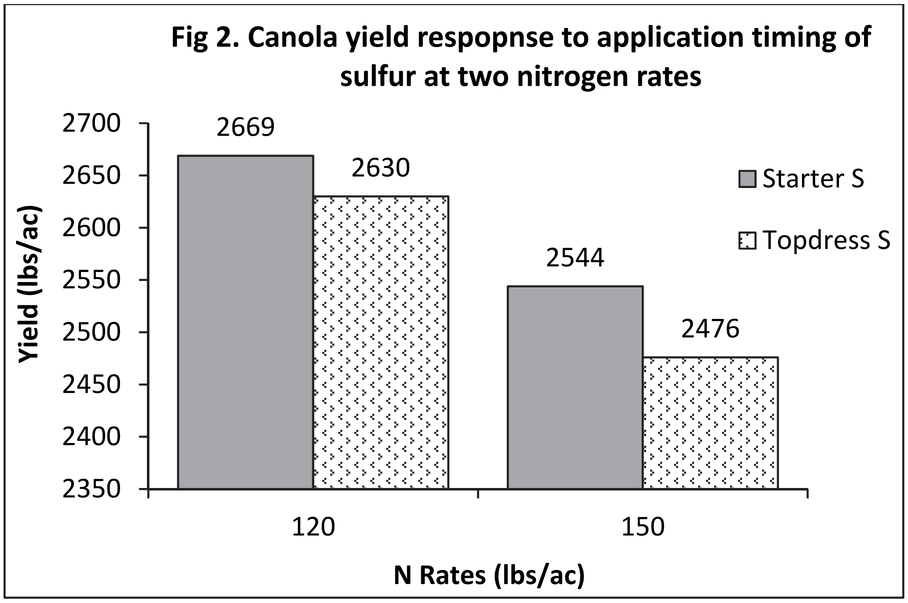
Results and discussion

Nitrogen fertilization significantly impacted yields but sulfur did not. Yields were lowest without application of N (2262 lbs/ac) and highest (2802 lbs/ac) for the split 150 lbs N (103 lbs applied + 47 lbs soil N) treatment of 110 lbs/ac (63 lbs N applied + 47 lbs soil N) preplant (starter) and 40 lbs topdress. At 90 lbs N, yield differences were not significant from the control plots or the 120 and 150 lb N rates. Above the 90 lbs N rate, yields were significantly greater than the control (Figure 1). Regarding the split N treatments that received 40 lbs topdress N, yields were not significantly different between the N sources even though consistently greater yields were observed with the Agrotain than with SuperU and plain urea treatments.

Fig 1. Effect of nitrogen rates on canola yield



Yields were not significantly impacted by S, which probably explained why there was no evidence of yield response to N rates at different levels of S. The high S requirement by canola and the lack of sulfur yield response, suggest that there was sufficient available residual S in the soil during early growth and probable contribution from the irrigation water. Without applied S, 150 lbs N (treatment 3) produced similar yields (2859 lbs/ac) to similar treatments (8 and 9) that received either 10 (2750 lbs/ac) or 20 lbs S (2651 lbs/ac). Even though preplant application of S fertilizer produced better yields than the midseason (topdress) S treatments the differences were not significant, which was consistent with the low response to S (Figure 2).



In conclusion, current practices to preplant apply N and S, and to apply S at the 20 lb rate to canola remain the more reliable practices that will ensure consistently better yields. Even though enhanced efficiency fertilizers like Agrotain are proven to minimize N loss from surface application of urea, studies need to demonstrate that the net yield advantage from these coated fertilizers is substantial enough to justify their high costs.

Summary of NDSU Extension 2021 Crop Surveys in South-Central North Dakota

Greg Endres and Carrie Nichols

Integrated pest management (IPM) survey
During the 2021 crop season, the annual IPM small grain, soybean and sunflower field survey was conducted across North Dakota by NDSU Extension, in cooperation with the North Dakota Department of Agriculture, to identify crop agronomic factors and presence of disease and insects. The survey data is used for educational and research programs for farmers, crop advisers, and personnel from university, government and ag industry. The survey data also supports export of ND crops.

Carrie Nichols, the crop scout based at the CREC, surveyed 404 fields in 11 south-central counties: Burleigh, Dickey, Eddy, Emmons, Foster, Kidder, LaMoure, Logan, McIntosh, Stutsman, and Wells.

The small grain survey was conducted in 136 **spring wheat** and 29 **barley** fields during June and July. Primary diseases targeted in the survey were bacterial leaf blight, barley yellow dwarf virus, rust (leaf, stem and stripe), Septoria, tan spot (wheat), net and spot blotch (barley), ergot, Fusarium head blight (scab) and loose smut. Primary insects surveyed were grasshoppers, aphids, wheat stem maggot and sawfly, and barley thrips.

The **soybean** survey was conducted in 133 fields during late June through mid-August to detect grasshoppers, soybean aphid, bean leaf beetle, spider mites and gall midge. Soybean aphids were first detected on July 12 but levels did not reach economic thresholds during the scouting period. Crops commonly grown prior to soybean: corn = 53%, small grain = 19% and soybean = 18%. Intermediate-spaced rows (12- to 24-inches) comprised 97% of surveyed fields.

The survey included 106 **sunflower** fields inspected for grasshoppers, red seed weevil, downy mildew, rust and verticillium wilt. Red sunflower weevils were found in 40% of fields. Corn was the most common crop that preceded sunflower (37% of total fields), followed by soybean (23%) and small grain (22%).

Maps displaying summaries of the state survey results by crop and pest are available at the following website: www.ag.ndsu.edu/ndipm

Insect traps were used during mid-June to mid-August in 4 **wheat** fields (CREC and Foster, McIntosh and Wells counties) to sample for armyworm, black cutworm and old world bollworm. Also, Arthur sunflower moth, banded sunflower moth and sunflower moth pheromone traps were located at the CREC to monitor the presence of these **sunflower** insects. All three moths were present in traps starting in July, with banded sunflower moth the most common. Also, Swede and canola flower midge traps were placed in a CREC **canola** trial. In addition, soil samples for nematodes were collected from 11 **wheat** fields (one per county) for the ND Dept. of Ag.

Sunflower survey
A **sunflower** field survey was conducted during fall 2021 by NDSU Extension in cooperation with the National Sunflower Association. Data collected included plant population, row spacing, tillage system, estimates of seed yield, and presence of or damage by birds, disease, insects and weeds. In south-central North Dakota, 15 fields were surveyed during September 15-21 in Eddy, Emmons, Foster, Logan, McIntosh, Sheridan, Stutsman and Wells counties by Greg Endres and Extension agents Chandy Howard, Emily Leier, Jeff Gale, Sheldon Gerhardt, Sarah Crimmins, Lindsay Maddock and Penny Nester.

Across these fields, average seed yield was estimated at 1780 lb/acre (range of 1180 to 2330 lb/acre). Harvestable stands averaged 17,200 plants/acre, with a range of 9,700 to 28,000 plants/acre. Most common prior crops were corn (67% of fields) or soybean (20%); fields were primarily reduced- or no-till (67%); and 80% of fields planted in 30-inch rows. Disease incidence, including sclerotinia and Phomopsis, generally was low. Seed loss from bird feeding was occurring in about half the fields during the survey period. Long-horned beetle larvae and associated stalk damage were found in 87% of fields. The most common yield-limiting factors were drought and bird feeding.

Details from the field surveys may be obtained by contacting the CREC.

Roughage Source Impacts on Feedlot Performance, Ruminal pH, and Ruminal Fermentation in Steers

Bryan W. Neville and Colin T. Tobin

Introduction
The availability of roughages that can be utilized in the northern Great Plains results in an increase in the variety of feedlot diets. Forage particle size can affect rumen pH (Beauchemin, 1991; Mertens, 1997). Understanding how roughage source impacts digestibility, fermentation, ruminal pH, and feedlot performance is a critical step to moving forward with feeding recommendations for this diverse set of roughage sources. Additionally, increases in availability of coproducts in the northern Great Plains, such as modified distiller’s grains with solubles (MDGS), requires further investigation of the use and optimal inclusion of the various roughage sources.

Understanding the abilities of a diverse set of roughages to regulate ruminal pH and fermentation is critical to improving the overall ability of producers to utilize a roughage at optimal concentrations to maximize grain inclusion while minimizing digestive upset and negative impacts to feed efficiency. Our hypothesis is that, when used on an equal roughage basis, roughage source may impact dry matter intake and ultimately feed efficiency in steers. Secondarily, we hypothesized that when used on an equal roughage basis, ruminal pH may still differ due to changes in overall physical properties of the various roughage sources. The objectives of this study were 1) to evaluate the impacts of roughage source on site of digestion, ruminal fermentation, and pH, and 2) to evaluate the impacts of roughage source on feedlot performance of steers fed diets containing 30% MDGS.

Materials and Methods

This study was approved by the North Dakota State University Institutional Animal Care and Use Committee prior to initiation of study procedures.

Feedlot Study

Animal Diets and Treatments. One-hundred sixty-five steer calves (581.5 ± 70.1 lbs) were used for this study. Steers were stratified by initial weight and randomly assigned to one of 15 feedlot pens with pen randomly assigned to treatment (n=5). Steers were subjected to two consecutive day weights at the beginning of the study and again at the conclusion of the project (d 210 and 211). Treatments were based on roughage source with one of the following 1) 20% dietary DM inclusion of corn silage (**CS**), and 2) 20% dietary DM inclusion of beet pulp with 3% straw (**BP**), and 3) 10% dietary DM inclusion of grass hay (**GH**). A fourth treatment in which wheat straw was to serve as the sole source of roughage was eliminated from the study because steers in the metabolism study had poor intake.

Steers fed differing roughage sources.

Adaptation was accomplished by making a series of five transition diets, with diets changed every 7 d until reaching the final finishing ration on day 28. Final finishing diet ingredients and nutrient composition are detailed in Table 1. The supplement was fed to provide 11.6 oz of monensin per steer per day. Feed bunks were managed to be devoid of feed prior to feeding the subsequent day. Feed delivery was recorded daily and feed refusals were collected and weighed weekly. All calves received a growth promotant implant (Synovex S, Zoetis Inc., Parsippany-Troy Hills, N.J.) at the initiation of the study, followed by a second growth promotant implant (Synovex Choice; Zoetis Inc.) on d 84 of the study. Additionally, all calves received a parasiticide pour-on (Cydectin, Bayer Animal Health, Shawnee Mission, KS) at arrival and a parasiticide pour-on (Clean-up II; Bayer Animal Health, Shawnee Mission, KS) on d 126. At the conclusion of the study, cattle were shipped to a commercial abattoir for slaughter and subsequent carcass data collection. Hot carcass weights were collected within 30 minutes of exsanguination. Ribeye area, 12th-rib fat, and marbling score were measured via automated camera imaging, while quality grade was assigned by USDA grader. All carcass data reported was provided by the abattoir.

Table 1. Ingredient and nutrient composition of diets fed to steers during feedlot study.

	Roughage Source[1]		
	GH	BP	CS
	--------------- % ---------------		
Ingredient			
Dry-Rolled Corn	56.7	43.7	46.7
MDGS	30	30	30
Grass Hay	10	--	--
Beet Pulp	--	20	--
Corn Silage	--	--	20
Cereal Straw	--	3	--
Calcium Carbonate	0.8	0.8	0.8
Supplement	2.5	2.5	2.5
Nutrient Composition[2]			
DM,%	72	54	57
CP, %	16.3	15.1	15.1
NEg, Mcal/kg	1.38	1.35	1.38

[1] Roughage source served as experimental treatment and were grass hay (GH), beet pulp (BP), and corn silage (CS).

[2] Calculated values based on NASEM (2016).

Metabolism Study

Animal Diets and Treatments.

Three ruminally- and duodenally-cannulated steers (1133.4 ± 116.2 lbs) were used in a 3 × 3 Latin square design to evaluate the impacts of replacement of corn silage with soybean hulls as roughage in high-concentrate finishing rations. Treatments were based on roughage source in the diet and consisted of 1) 20% dietary DM inclusion of corn silage (**CS**), and 2) 20% dietary DM inclusion of beet pulp (**BP**), and 3) 10% dietary DM inclusion of grass hay (**GH**). A fourth roughage treatment, where the sole source of roughage would have been wheat straw was removed from the study due to poor intake. Metabolism study diet ingredient composition and nutrient content are detailed in Table 2. Steers were housed in individual stations. Steers were fed a total-mixed ration two times a day at 0700 and 1900 and had continuous access to water. Feed was provided at a rate equal to: Intake, lb/d = 2.205 × (3.830 + (0.0143 × (BW × 0.96)) as suggested (NASEM, 2016). Feed offered was adjusted at the start of each study period. Orts, when present, were collected at 0700 each day prior to feeding.

Sample Collection. Sample collection and laboratory procedures largely followed those of Leupp et al. (2009) and Gilbery et al. (2007) and are detailed below. Each collection period consisted of a 7-day adaptation period, and 7-day collection period. Feed samples were collected once daily on days 7 through 14 and composited for each steer and period. Orts were collected from day 7 to day 14 and composited for each steer and period. Chromic oxide (.28 oz) was placed into gelatin capsules and ruminally dosed 2 times a day from day 4 to day 12 as an external marker. Duodenal fluid (3.38 oz) samples were collected on days 10 through 12 to allow for collection of a sample for every hour in a twelve-hour period (0700 to 1900). Duodenal samples were composited within each steer and period and frozen at -4º F until analysis. Fecal samples were immediately frozen and stored at -4º F before being composited and mixed with a rotary mixer (model H-600, Hobart Manufacturing Co., Troy, OH).

Rumen fluid was collected on day 13 at -2, 0, 2, 4, 6, 8, 10 and 12 h relative to feeding. Using a suction strainer, 3.38 oz of rumen fluid was collected, and pH was recorded using a pH meter (Symphony B10P; VWR International, LLC., Radnor PA). Immediately following determination of pH, rumen fluid was acidified with 1 mL of 7.2N sulfuric acid and stored in a freezer at -4º F.

Table 2. Ingredient and nutrient composition of diets fed to steers during metabolism study.

	Roughage Source[1]		
	GH	BP	CS
	--------------- % ---------------		
Ingredient			
Dry-Rolled Corn	56.7	46.7	46.7
MDGS	30	30	30
Grass Hay	10	--	--
Beet Pulp	--	20	--
Corn Silage	--	--	20
Calcium Carbonate	0.8	0.8	0.8
Supplement	2.5	2.5	2.5
Nutrient Composition[2]			
DM,%	72	54	57
CP, %	15.3	15.1	15.1
Neg, Mcal/kg	1.38	1.35	1.38

[1] Roughage source served as experimental treatment and were grass hay (GH), beet pulp (BP), and corn silage (CS).

[2] Calculated values based on NASEM (2016).

Statistical Analysis

Feedlot data were analyzed with the mixed procedures of SAS (SAS Ins. Inc., Cary, N.C.). All data were analyzed with pen serving as the experimental unit. For data collected on individual animal basis including body weight, average daily gain, and carcass characteristics, pen values were generated by averaging the respective individual animal values within a pen. The model included the effect of treatment. Metabolism data were analyzed as a 3 × 3 Latin Square using the Mixed procedures of SAS (SAS Inst. Inc., Cary, NC). The model included effects of period and treatment as fixed effects. Data over time were analyzed as repeated measures design using the Mixed procedures of SAS.

Results and Discussion

Steer body weight, ADG, DMI, and G:F were not affected by dietary roughage source ($P \geq 0.56$). Hot carcass weight was greater for steers fed either GH or CS ($P \leq 0.01$) compared to those fed BP as a source of roughage. Backfat was greater for steers fed CS when compared to those fed BP ($P = 0.02$), with steers fed GH as a source or roughage being intermediate and similar to both BP and CS fed steers ($P \geq 0.16$) (Table 3). There were no differences in ribeye area, marbling, quality grade, or yield grade due to roughage source ($P \geq 0.13$). In the metabolism study, ruminal pH was not affected by roughage type and averaged 6.15 ± 0.06 ($P = 0.19$). Previous research has shown decreased feed intake when beet pulp was stored prior to feeding but no differences in intake when beet pulp was fed fresh (Park et al., 2001). The latter response was also observed in the current study as beet pulp in the current study was not stored for extended periods of time prior to feeding. Park et al. (2001) also reported decreased ADG in response to replacing corn silage with beet pulp. Mader et al. (1991) reported decreased DMI and feed:gain in steers fed dry-rolled corn-based finishing diets, which was not the case in the current study. Similar to the results of the current study, HCW and backfat were decreased in steers fed beet pulp compared to those fed corn silage (Park et al., 2001). Roughage sources including alfalfa hay, corn stalks and corn silage have been reported to result in differences in backfat thickness when WDGS was included in the diet (Benton et al., 2015). The similar ruminal pH found between GH, BP, and CS was not expected. We had anticipated that feeding beet pulp may have resulted in lower pH due to less physically effective fiber, but that was not the case.

Table 3. Feedlot performance and carcass characterisitcs of steers fed different roughage sources.

	Roughage Source[1]				
	GH	BP	CS	SEM	*P*-value
Feedlot Performance					
Initial BW, lbs	581.0	585.4	581.7	2.2	0.8
Final BW, lbs	1427.7	1418.7	1426.9	7.3	0.6
DMI, lbs/d	22.7	22.3	22.7	0.3	0.6
ADG, lbs/d	4.0	4.0	4.0	0.0	0.7
G:F[2]	0.4	0.4	0.4	0.0	0.9
Carcass Characteristics					
HCW[3], lbs	883.5[a]	861.7[b]	885.3[a]	5.3	0.0
Ribeye area, in^2	13.4	12.9	13.2	0.2	0.2
Marbling Score[4]	529.0	552.0	557.0	19.3	0.6
Back Fat, in	0.709[ab]	0.654[a]	0.772[b]	0.029	0.1
Quality Grade[5]	10.8	11.1	11.0	0.2	0.6
Yield Grade	3.7	3.7	4.0	0.1	0.1

[1] Roughage source served as experimental treatment and were grass hay (GH), beet pulp (BP), and corn silage (CS).

[2] G:F = lbs weight gain : lbs of dry feed

[3] Hot carcass weight.

[4] Marbling score based on 400 = Small[00].

[5] Quality grades based on Low Choice (Ch-) = 10, High Prime (Pr+) = 15.

Conclusion

In conclusion, there were advantages in hot carcass weight to feeding either grass hay or corn silage compared to beet pulp. As hot carcass weight typically is the basis for sale price of fed cattle, the approximate 22.2-24.3 lb greater carcass weights would result in greater carcass value. Continued evaluation to ascertain cost of gain is still needed to make any recommendations.

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Discovering Value in North Dakota Calves: Dakota Feeder Calf Show XX

Karl Hoppe, Colin Tobin, and Dakota Feeder Calf Show Livestock Committee

North Dakota cattle producers participated in the Dakota Feeder Calf Show feedout project to identify superior growth, carcass characteristics and profit. The difference in profitability between consignments from the top five herds and the bottom five herds was $189.03 per head for the 2020-2021 feeding period.

The Dakota Feeder Calf Show is a feedout project where cattle producers can learn more about the feeding performance, carcass characteristics and profitability of their steers. Through involvement in this calf value discovery program, cow-calf producers can benchmark performance and identify superior genetics when fed with common feedlot management.

The calves were received in groups of three or four on October 17, 2020, at the Turtle Lake Weighing Station, Turtle Lake, N.D., for weighing, tagging, veterinary processing and showing. The calves were evaluated for conformation and uniformity, with the judges providing a discussion to the owners at the beginning of the feedout. The number of cattle consigned was 122, of which 104 competed in the pen-of-three contest.

The calves were shipped to the Carrington Research Extension Center, for feeding. Prior to shipment, calves were vaccinated, implanted with Synovex-S, dewormed and injected with a prophylactic long-acting antibiotic.

Calves were sorted and placed on corn-based receiving diets. After an eight-week backgrounding period, the calves were transitioned to a 0.62 megacalorie of net energy for gain (Mcal NEg) per pound finishing diet. Cattle were weighed every 28 days, and updated performance reports were provided to the owners. Cattle were re-implanted with Synovex-Choice.

Due to Covid 19 pandemic restrictions, no formal meeting was conducted for reviewing cattle while being fed. Instead, the cattle owners were invited to review the calves any time prior to harvest.

The cattle were harvested on May 26, 2021 (117 head). The cattle were sold to Tyson Fresh Meats, Dakota City, Nebraska, on a grid basis, with premiums and discounts based on carcass quality. Carcass data were collected after harvest.

Cattle consigned to the Dakota Feeder Calf Show feedout project averaged 602.5 pounds upon delivery to the Carrington Research Extension Center Livestock Unit on October 17, 2020. After an average 222-day feeding period, cattle averaged 1,374.9 pounds (at plant, shrunk weight). Death loss was 3.28 percent (four head) during the feeding period.

Average daily feed intake per head was 36.0 pounds on an as-fed basis and 23.8 pounds on a dry-matter basis. Pounds of feed required per pound of gain were 11.0 on an as-fed basis and 7.27 pounds on a dry-matter basis.

The overall feed cost per pound of gain was $0.581. The overall yardage cost per pound of gain was $0.103. The combined cost per pound of gain, including feed, yardage, veterinary, trucking and other expenses except interest, was $0.829.

Calves were priced by weight upon delivery to the feedlot. The pricing equation ($ per 100 pounds = (-0.031048183 x initial calf weight, pounds) + 165.6103046) was determined by regression analysis on local livestock auction prices reported for the weeks before and after delivery.

Overall, the carcasses contained U.S. Department of Agriculture Quality Grades at 10.2 percent Prime, 79.6 percent Choice (including 22.9 percent Certified Angus Beef), and 10.2 percent Select, and USDA Yield Grades at 1.7 percent YG1, 19.5 percent YG2, 39.0 percent YG3, 32.2 percent YG4 and 7.6 percent YG5.

Carcass value per 100 pounds (cwt) was calculated using the actual base carcass price plus premiums and discounts for each carcass. The grid price received for May 26, 2021, was $194.43 Choice YG3 base with premiums: Prime $15, CAB $6, YG1 $6.50 and YG2 $3, and discounts: Select minus $14, Standard (no roll) minus $15, YG4 minus $8, YG5 minus $20 and carcasses greater than 1050 pounds minus $20.

Results from the calves selected for the pen-of-three competition are listed in Table 1.

Overall, the pen-of-three calves averaged 420 days of age and 1,435.6 pounds per head at harvest. The overall pen-of-three feedlot average daily gain was 3.54 pounds, while weight gain per day of age was 3.30 pounds. The overall pen-of-three marbling score was 543.6 (average choice, modest marbling).

The top-profit pen-of-three calves with superior genetics returned $367.58 per head, while the bottom pen-of-three calves returned $90.65 per head. The average of the five top-scoring pens of steers averaged $320.86 per head, while the average of the bottom five scoring pens of steers averaged $131.84 per head.

For the pen-of-three competition, average profit was $196.70 per head. The spread in profitability between the top and bottom five herds was $189.02 per head.

Superior feedlot weight gain and carcass characteristics enhance calf value. Exceptional average daily gains, weight per day of age, harvest weight and marbling score are identified in North Dakota beef herds. Feedout projects provide a source of information for cattle producers to learn about feedlot performance and individual animal differences, and discover cattle value.

Table 1. Feeding performance - 2020-2021 Dakota Feeder Calf Show Feedout								
Pen of three	Best Three Score Total	Average Birth Date	Average Weight per Day of Age, lbs	Average Harvest Weight, lbs.	Average Daily Gain, lbs.	Average Marbling Score (1)	Ave Calculated Yield Grade	Ave Feeding Profit or Loss / Head
1	3.026	28-Feb-20	3.03	1420.8	3.85	741.3	3.531	367.58
2	2.643	21-Mar-20	3.36	1502.5	3.57	656.0	3.380	305.21
3	2.624	10-Mar-20	3.31	1513.3	3.63	629.0	3.247	297.89
4	2.571	2-Mar-20	2.86	1332.5	3.24	544.0	2.663	317.79
5	2.468	14-Apr-20	3.27	1377.5	3.89	580.0	3.972	315.86
Average top 5 herds	2.666	15-Mar-20	3.165	1429.333	3.635	630.067	3.359	$ 320.87
6	2.394	16-Mar-20	3.20	1448.3	3.45	605.7	3.804	301.56
7	2.342	16-Mar-20	3.21	1450.0	3.51	582.7	3.413	258.65
8	2.235	3-May-20	3.55	1429.2	3.83	405.0	2.923	257.78
9	2.211	20-Mar-20	3.28	1467.5	3.60	561.0	3.676	243.16
10	2.206	26-Mar-20	3.61	1595.8	3.87	605.3	4.087	224.95
11	2.189	24-Apr-20	3.34	1375.0	3.48	456.0	2.894	241.62
12	2.147	14-Apr-20	3.21	1353.3	3.63	631.7	4.345	234.57
13	2.142	19-Mar-20	3.31	1486.7	3.41	583.7	3.523	210.51
14	2.090	13-Apr-20	3.31	1398.3	3.39	534.3	3.576	229.58
15	2.065	23-Apr-20	3.72	1535.0	4.00	528.0	3.935	199.56
16	1.993	8-Apr-20	3.56	1519.2	3.82	428.0	3.275	195.94
17	1.936	9-May-20	3.48	1375.0	3.56	496.0	3.928	217.25
18	1.842	13-Apr-20	3.08	1302.5	3.58	435.0	3.289	164.94
19	1.829	26-Mar-20	3.14	1387.5	3.40	478.0	3.026	127.65
20	1.815	15-Apr-20	3.08	1296.7	3.34	611.7	4.013	134.38
21	1.793	3-Apr-20	3.79	1641.7	3.62	491.0	4.056	178.84
22	1.768	6-Apr-20	3.46	1489.2	3.54	514.7	4.235	178.87
23	1.757	25-Mar-20	3.31	1460.8	3.34	578.7	4.367	166.50
24	1.667	4-Apr-20	3.14	1354.2	3.04	534.7	3.228	90.65
25	1.535	7-Apr-20	3.47	1490.8	3.34	561.0	5.031	128.59
26	1.282	25-Mar-20	3.75	1660.8	4.10	473.3	5.427	94.60
Average bottom 5 herds	1.602	1-Apr-20	3.425	1491.2	3.473	532.5	4.458	$ 131.84
Overall average - pens of three	2.101	1-Apr-20	3.30	1435.63	3.54	543.62	3.76	196.70
Standard deviation		17.8	0.23	95.52	0.25	78.09	0.64	72.60
number		26	26	26	26	26	26	26

(1) Marbling score 300-399 = select, 400-499 = low choice, 500-599 = average choice, 600-699 = high choice, 700-799 = low prime

Exploring Feeding Performance of Yearling Angus Cattle – ND Angus University Feedout

Karl Hoppe and Colin Tobin

Black Angus yearling cattle were consigned by ten producers for feeding to slaughter weight. Feeding performance and carcass characteristics were measured and shared with owners. Feed conversion by owner ranged from 7.61 to 10.18 pounds of feed per pound of gain. Profitability ranged from $84.94 to ($154.80) per head for the 2021 feeding period.

The North Dakota Angus University Feedout program is a summer, retained-ownership project where cattle producers raising black Angus cattle can learn more about the feeding performance, carcass characteristics and profitability of their yearling steers.

Through involvement in this calf value discovery program, cow-calf producers can benchmark performance and identify superior genetics when fed with common feedlot management.

Calves (141 head) were received in groups ranging from 4 to 32 head from ten owners prior to June 14, 2021. Upon delivery to the Carrington Research Extension Center Livestock Unit, calves were weighed, tagged, and veterinary processed.

Calves were penned by owner and provided a corn-based receiving diet. After a 10-day ration adaption, the calves were transitioned to a 0.62 megacalorie of net energy for gain (Mcal NEg) per pound finishing diet. Cattle were weighed every 28 days, and updated performance reports were provided to the owners. Cattle were implanted with Synovex-Choice.

Cattle owners were invited to review their calves any time prior to harvest.

The cattle were harvested on October 7, 2021 (138 head). The cattle were sold to Demkota, Aberdeen, South Dakota on a grid basis, with premiums and discounts based on carcass quality. Carcass data were collected after harvest.

Cattle consigned averaged 958.9 pounds upon delivery to the Carrington Research Extension Center Livestock Unit on June 14, 2021. After a 141-day feeding period, cattle averaged 1405.0 pounds (at plant, shrunk weight). Death loss was 2.13 percent (3 head) during the feeding period.

Average daily feed intake per head was 42.3 pounds on an as-fed basis and 33.0 pounds on a dry-matter basis. Pounds of feed required per pound of gain were 11.6 on an as-fed basis and 9.0 pounds on a dry-matter basis.

The overall feed cost per pound of gain was $1.00. The overall yardage cost per pound of gain was $0.109. The combined cost per pound of gain, including feed, yardage, veterinary, trucking and other expenses except interest, was $1.25.

Calves were priced by weight upon delivery to the feedlot. The pricing equation ($ per 100 pounds = (-0.093263371* initial calf weight, pounds) + 216.0826063) was determined by regression analysis on local livestock auction prices reported for the weeks before and after delivery.

Overall, the carcasses contained U.S. Department of Agriculture Quality Grades at 7.9 percent Prime, 78.2 percent Choice (including 45.6 percent Certified Angus Beef), 12.3 percent Select, and 1.6 percent no roll. USDA Yield Grades for the carcasses were 21.0 percent YG2, 69.5 percent YG3, 8.7 percent YG4 and 0.8 percent YG5. One carcass weighed greater than 1050 pounds.

Carcass value per 100 pounds (cwt) was calculated using the actual base carcass price plus premiums and discounts for each carcass. The grid price received for May 26, 2021, was $196 Choice YG3 base with premiums: Prime $15, CAB $3, YG1 $6 and YG2 $3, and discounts: Select $4.20, Standard (no roll) $25, YG4 $10, YG5 $25 and carcasses greater than 1050 pounds $20.

Feeding results from the calves by owner are listed in Table 1.

The top-profit pen of calves returned $84.98 per head, while the bottom calves returned ($154.80) per head. The spread between the top profit pen and the lowest profit pen was $239.78 per head.

Yearling Angus steer performance varied between owners. Feed conversion ranged from 7.6 to 10.2 pounds dry matter fed per pound of gain. Average daily gain ranged from 2.81 to 4.63.

Feedout projects provide cattle producers an opportunity to learn about feedlot performance, individual carcass differences, and discover cattle value.

Table 1. ND Angus University Feedout 2021.

pen	no. head	no. died	weight in	weight end	ADG	Dry matter Feed/gain	feed cost of gain	total cost of gain	% Prime	%CAB	Profit/head
1	15	0	933.3	1474.4	4.22	8.22	$ 0.916	$ 1.143	6.7	66.7	$ 47.38
2	16	1	965.0	1427.4	3.27	10.18	$ 1.135	$ 1.398	31.3	25.0	$ (83.66)
3	16	1	994.9	1403.2	2.81	10.07	$ 1.123	$ 1.439	-	68.8	$ (46.12)
4	11	0	905.4	1433.0	4.63	7.61	$ 0.848	$ 1.039	-	27.3	$ (57.52)
5	32	1	975.3	1426.8	3.57	9.38	$ 1.045	$ 1.290	9.4	46.9	$ (46.67)
6	19	0	883.9	1276.0	3.44	9.32	$ 1.038	$ 1.289	-	31.6	$ (154.80)
7	5	0	1001.6	1482.6	4.22	8.35	$ 0.931	$ 1.142	20.0	40.0	$ 84.98
8	10	0	836.4	1271.2	3.81	8.53	$ 0.950	$ 1.177	-	30.0	$ (153.46)
9	13	0	1044.9	1479.3	3.81	9.28	$ 1.034	$ 1.267	-	53.8	$ 6.79
10	4	0	1009.5	1431.8	3.70	7.94	$ 0.884	$ 1.123	25.0	50.0	$ 41.57
overall	141	3	958.9	1405.0	3.65	9.04	1.000	1.250	7.90	45.60	$ (51.69)
std dev	7.9	0.5	64.4	76.8	0.5	0.9	0.1	0.1	11.94	15.90	81.9
number	10	10	10	10	10	10	10	10	10	10	10

SARE Discovery - Providing Experiences for Educators

Karl Hoppe

Providing experiences in sustainable and regenerative agriculture production helps educators.

The Sustainable Agriculture Research and Education (SARE) program has been funded by the United States Department of Agriculture (USDA) for over 30 years and provides a wide variety of information at www.SARE.org. Extension agents and educators are familiar with the terms ‘sustainable’ and ‘regenerative,’ however, some educators are unaware of the tremendous SARE history or depth of involvement SARE has in agriculture.

The SARE Discovery program is a yearlong program arranged to provide Extension agent educators an awareness and understanding of SARE involvement in North Dakota. Agents will become familiar with sustainable producer groups, non-governmental organizations, and individuals leading the sustainable and regenerative practices for agriculture.

Discovery sessions include one of each of the following:
Session 1 – Regenerative Ag
Session 2 – SARE Farmer and Rancher Grant program
Session 3 – Local Foods effort
Session 4 – NPSAS sustainable Ag conference
Session 5 – FARRMS
Session 6 – Organic Farming
Session 7 – Regional or National Sustainable Ag conference
Session 8 – Research and Education Grant program
Session 9 – 1994 Land Grant Colleges in North Dakota
Session 10 – Conservation partners – NRCS and SCDs, Leopold program – ND recipients

The sessions are an organized discussion of the SARE program. For example, an interview with the SARE farmer rancher grant recipient would first start with an overview of the Farmer Rancher grant process with emphasis on competitive grant writing for SARE grants. Then an on-farm experience with a farmer rancher grant recipient discussing why they applied for the grant, sustainable issues involved, what worked and didn't work, how grant funds were used, SARE reporting requirements and efforts, and how results were shared with the community. Each interview would culminate with a reporting effort by each agent. The reporting effort is either a blog, a pod cast, a news column, video, on-line diary, or other method for documenting what was learned.

Agents involved in the SARE Discovery program should develop a long-term interest in sustainability with continued professional development supported by the ND State SARE PDP program. Involvement in the SARE Discovery program will lead to marketing of SARE programs, information and grants to colleagues and clients. In addition, outreach to the 1994 land grant colleges and tribal constituents about SARE is encouraged.

Northern-Hardy Fruit Evaluation Project: Drought Persists, SWD Absent

Kathy Wiederholt

In 2021, the Northern Hardy Fruit Evaluation Project provided distance learning for approximately 900 people through videos and webinars. Our in-person field day was attended by 55 people and featured TrimTab Agriculture, Sioux City, Iowa. We served over 130 people and educators in-state through calls and email, plus people in Nebraska, South Dakota, Minnesota, Montana, Kentucky and Alaska.

In fall 2020, we received only 1.06" of rain after a dry season. 2021 spring rain was about 50% short while summer was 75% short. There was almost no rain from the end of June until mid-August. Rain began regularly and we received 8.2 inches from late August to late October. This saved the aronia and apple crops and prepared perennials for winter.

Winter 2020-21 was warmer than usual; both the high and low temperatures were over 5°F warmer than the 20-year averages. Snowfall was 25.8 inches, with generally thin coverage through April. Spring 2021 temperatures were close to average and blossoming was good despite the ongoing drought effects. Summer was about 5°F warmer and about 75% drier than typical.

Drought was expected so water was supplied to all the crops by drip irrigation from June through October at about 1 gallon per foot of drip tape row. The plants were also fertilized twice with 0.25 oz N per plant. Water is supplied with a 1,200 gallon-tank and gravity fed into the head tubing. This is a slow application but requires no other equipment to maintain.

Spotted Wing Drosophila (SWD) fruit flies were only found in one berry in 2021. The spray program was implemented June 15 and the dry weather was not conducive to their reproduction. We hope that both dry conditions and the spray program this year allow us to stay ahead of the problem in the future.

Notable events in the fruit orchard:

- 'Juliet' cherry was harvested with no SWD loss – a first since 2012. 'Romeo' produces a lot less fruit and is ripe after 'Juliet'. The squirrels eat them early in the mornings and break branches. The squirrels also chew the irrigation lines. Some control measures seem to be in order.
- Red and black currant production was nil this year due to additional pruning to reduce currant borer populations. The borer has become a big problem. It is suggested to only control it by pruning but this does not seem to work well. Infested branches produce fruit but they also harbor larvae. Traps will be used in 2022.
- Black currants that had some fruit lost most of their berries despite irrigation. Ripening was uneven; ripe fruit fell while green berries were still present. A local grower that did not irrigate lost their fruit earlier, in the green-fruit stage.

- All apples ripened unevenly. ‘Zestar!’ and ‘Hazen’ apples had small crops this year. ‘Hazen’ were dry/mealy and not fit to eat, though they looked good. The late apples, ‘Honeycrisp, Haralred and Sweet 16’, had respectable crops. These were watered in fall 2020 and through August 2021, however, the rain after August 20 made the crop.
- Aronia shrubs were loaded with fruit this year. Since the crop was lost to drought in 2020, we irrigated regularly. The crop stayed on and after several rains, the fruit swelled and were some of the nicest berries of any year.

Northern Hardy Fruit Project - Yearly Production Records										
		No. of plants	**2018**		**2019**		**2020**		**2021**	
			Date	pounds	Date	pounds	Date	pounds	Date	pounds
Aronia	Nero	4	9/10-11	105.8	17-Sep	19.4	19-Sep	26.3	15-Sep	70.5
	Raintree Seedling	4	12-Sep	70.3	18-Sep	11.8	10-Sep	15.1	15-Sep	47.6
	Raintree Select	4	8/31-9/5	94.2	13-Sep	23.0	11-Sep	14.4	12-Sep	95.4
	Viking	4	8/22-9/5	105.7	16-Sep	27.8	14-Sep	NA	8-Sep	104.5
	McKenzie	4	8/28-30	78.0	16-Sep	37.0	14-Sep	NA	14-Sep	78.6
	Galicjanka	4	27-Aug	29.0	13-Sep	23.9	12-Sep	4.3	8-Sep	49.1
				483.0		**142.9**		**apx. 90**		**445.7**
			Overcropped		*Hail, SWD loss*		*Drought, fruit dropped*		*Drought, irrigated*	
Hardy Cherries	SK Carmine Jewel	0	12-Jul	x	*Removed*	*Removed*	*Removed*	*Removed*	*Removed*	*Removed*
	SK Crimson Passi	0	13-Jul	x	*Removed*	*Removed*	*Removed*	*Removed*	*Removed*	*Removed*
	Evans / Bali	2	20-Jul	x	30-Jul	53.5	29-Jul	*SWD loss*	*Removed*	*Removed*
	SK Romeo	3			31-Jul	11.5	26-Jul	*Birds*	26-Jul	*Birds*
	SK Juliet	5			17-Jul	46.2	13-Jul	41.0	16-Jul	73.8
						111.2		**41.0**		**73.8**
			SWD loss		*SWD loss*		*Still SWD loss in all*		*Drought, No SWD*	
New	*Cheakamus*	7	31-Jul	79.8	7-Aug	63.9	5-Aug	19.2	*did not pick*	NA
Black Currant	*Stikine*	7	7/18-24	52.2	7/31-8/5	58.1	8-5	12.4	*did not pick*	NA
Variety Trial	*Tahsis*	8	26-Jul	83.5	7/31-8/6	76.9	30-Jul	47.6	*did not pick*	NA
	Tiben	8	6-Aug	82.2	16-Aug	79.2	14-Aug	64.0	*did not pick*	NA
	Tofino	0	8-Aug	14.3	*Removed*	*Removed*	*Removed*	*Removed*	*did not pick*	NA
	Nechako - 2 ft spac	7	9-Aug	12.7	20-Aug	14.4	13-Aug	6.8	*did not pick*	NA
	Nechako - 3 ft spac	7	9-Aug	18.6	20-Aug	25.4	13-Aug	9.4	*did not pick*	NA
				404.2		**379.6**		**207.6**		**0.0**
			Borer prune, some SWD		*Pruning Summer*		*SWD, sum'r pruning*		*Borer pruning*	
Black Currant	Ben Lomand	4	25-Jul	4.9	30-Jul	7.2	27-Jul	3.4	*did not pick*	NA
	Blackcomb	4	1-Aug	17.6	15-Aug	38.3	12-Aug	19.8	*did not pick*	NA
	Champion	4	25-Jul	11.5	30-Jul	9.6	30-Jul	6.4	*did not pick*	NA
	Minaj Smyriou	4	18-Jul	5.5	x	*SWD loss*	27-Jul	6.6	*did not pick*	NA
				39.5		**55.1**		**36.2**		**0.0**
			Recovery year		*SWD losses*		*SWD losses in all*		*Borer pruning*	
Red Currant	Jhonkheer Van Te	4	25-Jul	3.2	24-Jul	39.5	*x*	*x*	*did not pick*	*NA*
	Rosetta	4	*SWD*	x	2-Aug	37.8	*2019 fall freeze; no fruit*		*did not pick*	NA
	Rovada	4	7/25-8/1	12.4	8/1	56.3	*2019 fall freeze; no fruit*		*did not pick*	NA
				15.6		**133.4**		**133.4**		**0.0**
			Pruned for Borer 2018		*SWD losses*		*SWD losses*		*Borer pruning*	

Northern Hardy Fruit Project - Yearly Production Records (cont.)

		No. of plants	2018		2019		2020		2021	
			Date	pounds	Date	pounds	Date	pounds	Date	pounds
Juneberry	*Honeywood*	20/15 2021	7/10	68.3	15-Jul	14.0	8-Jul	NA	6-Jul	NA
Variety Trial	*JB30*	20/15 2021	7/5	60.8	15-Jul	14.0	6-Jul	NA	30-Jun	NA
	Martin	20/15 2021	7/5	68.6	15-Jul	14.0	6-Jul	NA	30-Jun	NA
	Smoky	20/15 2021	7/11	115.9	x	x	10-Jul	NA	6-Jul	NA
	Thiessen	20/15 2021	7/6	60.0	15-Jul	14.0	6-Jul	NA	30-Jun	NA
				373.6		**Est 4-500 lbs**		**EST. 5-600 lbs**		**EST. 4-500 lbs**
			Only 2 of 4 rows picked		*Early SWD. Lost*		*Covid; open picking*		*Remv'd 1/4, open pick*	

The Project was planted in 2007, except Juneberries 2006.

		No. of plants	Date	pounds	Date	pounds	Date	pounds	Date	pounds
Japanese										
Haskap	43-87	3/0 2021	22-Jun	7.9	12-Jul	NA	*did not pick*	x	*did not pick*	x
2007	43-97	3/0 2021	28-Jun	x	12-Jul	NA	*did not pick*	x	*did not pick*	x
2012	20-04	3/0 2021	26-Jun	3.2	*Fruit fell earl*	x	*did not pick*	x	*Removed*	x
	21-20	3/1 2021	2-Jul	5.9	12-Jul	NA	*did not pick*	x	30-Jun	2.4
	22-14	3/1 2021	28-Jun	6.5	10-Jul	4.8	*did not pick*	x	16-Jul	1.5
	22-26	3/1 2021	26-Jun	8.9	12-Jul	NA	*did not pick*	x	15-Jul	2.1
	41-75	3/1 2021	6/27-7/2	15.8	8-Jul	10.3	*did not pick*	x	27-Jun	2.3
	44-19	3/1 2021	2-Jul	7.1	12-Jul	NA	*did not pick*	x	19-Jul	2.5
	57-49	3/1 2021	2-Jul	10.1	10-Jul	21.8	*did not pick*	x	9-Jul	2.4
	88-92	3/1 2021	27-Jun	6.2	8-Jul	5.8	*did not pick*	x	27-Jun	1.5
	88-102	3/1 2021	26-Jun	4.7	5-Jul	12.9	*did not pick*	x	27-Jun	2.6
	108-23	3/1 2021	26-Jun	8.9	5-Jul	18.0	*did not pick*	x	27-Jun	5.2
	131-08	3/0 2021	5-Jul	8.7	12-Jul	NA	*Removed*	x	*Removed*	x
	142-30	3/1 2021	28-Jun	5.7	10-Jul	9.5	*did not pick*	x	6-Jul	1.6
	78-89	2	5-Jul	3.5	10-Jul	4.7	*did not pick*	x	6-Jul	5.3
				116.3		**87.8**	*Covid &*	**0.0**		**29.6**
					NA: quick pick, SWD		*Heavy prune, left to birds*			
Japanese	21-17	2					13-Jul	0.5	19-Jul	1.5
Haskap	67-95	1					13-Jul	1.7	19-Jul	3.0
2017	100-22	1					29-Jun	1.3	21-Jun	2.2
	108-42	2					2-Jul	3.3	27-Jun	5.1
	110-26	2					2-Jul	1.4	30-Jun	3.5
	120-10	2					2-Jul	1.0	11-Jul	2.3
	120-14	2					29-Jun	1.6	27-Jun	2.1
	120-16	2					5-Jul	2.7	2-Jul	2.9
	122-03	2					11-Jul	0.9	4-Jul	5.6
	122-12	2					7-Jul	1.4	15-Jul	2.7
	122-16	1					29-Jun	0.2	9-Jul	0.4
	123-05	2					7-Jul	2.3	15-Jul	3.5
	125-04	1					NA	x	4-Jul	0.4
	132-09	2					29-Jun	0.2	21-Jun	2.5
	132-10	1					6-Jul	x	27-Jun	1.0
	132-13	1					29-Jun	0.5	4-Jul	1.0
	132-14	2					29-Jun	1.2	27-Jun	1.4
	139-24	5					5-Jul	8.0	7-Jul	9.6
	142-31	2					13-Jul	0.5	13-Jul	2.0
	144-04	1					2-Jul	0.5	30-Jun	1.1
	145-10	2					7-Jul	x	6-Jul	0.6
								24.4		**54.5**
							1st year of production			

Northern Hardy Fruit Project - Yearly Production Records (cont.)										
Japanese	111-12	2							11-Jul	0.8
Haskap	124-16	2							11-Jul	0.5
2018	124-19	1							19-Jul	0.6
	125-13	2							19-Jul	1.5
	129-06	2							30-Jun	0.5
	130-09	2							19-Jul	0.3
	135-03	2							9-Jul	0.2
										4.4
									1st year of production	
		No. of plants	**2018**		**2019**		**2020**		**2021**	
			Date	pounds	Date	pounds	Date	pounds	Date	pounds
Russian	Berry Blue	4	*did not pick*	x	*did not pick*	x	*did not pick*	x	*did not pick*	x
Honeyberry	Blue Belle	4	*did not pick*	x	2-Jul	28.0	*did not pick*	x	*did not pick*	x
	Kamchatka	4	*did not pick*	x	*did not pick*	x	*did not pick*	x	*did not pick*	x
				0.0		**28.0**		**0.0**		**0.0**
					Left for birds		*Left for birds*		*Left for birds*	
Haskaps	Boreal Beast	1							7/6	0.6
Canadian	Boreal Beauty	2							7/4-13	1.7
	Boreal Blizzard	1							4-Jul	0.4
	Aurora	2							>7/20	x
	Borealis	1	22-Jun	0.2	*did not pick*	x	*did not pick*	x	*did not pick*	x
	Tundra	1	21-Jun	4.8	*did not pick*	x	*did not pick*	x	*did not pick*	x
	Indigo Gem (9-15)	4	21-Jun	3.6	*did not pick*	x	*did not pick*	x	*did not pick*	x
	Indigo Treat (9-91)	0	21-Jun	3.7	*did not pick*	x	*did not pick*	x	*did not pick*	x
	Aurora	3	2-Jul	0.3	*did not pick*	x	*did not pick*	x	*did not pick*	x
				12.6		**0.0**		**0.0**		**0.0**
					Left for birds		*Left for birds*		*Left for birds*	

Picking aronia berries.

Weather Summary

Monthly Temperatures (°F) and Normals

Month	Max Temp				Min Temp				Monthly Avg. Temp			
	2021	Norm*	2020	2019	2021	Norm*	2020	2019	2021	Norm*	2020	2019
Apr	54	55	48	51	27	31	26	31	40	43	37	41
May	66	68	63	63	40	43	41	38	53	56	52	50
June	83	76	81	77	55	53	55	53	69	64	68	65
July	86	82	81	80	60	58	60	58	73	70	71	69
Aug	83	81	79	75	56	55	56	53	69	68	67	64
Sept	75	71	70	68	49	45	44	48	62	58	57	58
Avgs:	74	72	70	69	48	47	47	47	61	60	59	58

*Normals = 1981-2010 averages

Monthly Precipitation (in) and Normals

Month	2021 Monthly Precipitation* NDAWN	NOAA	Normal[1]	2020	2019
Apr	0.51	0.49	1.17	0.45	0.92
May	1.35	1.49	2.76	1.18	1.46
June	1.82	2.44	3.77	1.23	3.00
July	0.13	0.15	3.39	5.00	3.64
Aug	2.56	2.65	2.31	1.06	3.08
Sept	1.96	1.98	1.91	0.13	8.26
Totals:	8.34	9.20	15.31	9.04	20.36

[1] Normals = 1981-2010 averages * NDAWN and NOAA are two different weather stations at the CREC.

Monthly Growing Degree Days and Normals

Month	Wheat GDD				Sunflower GDD				Corn GDD			
	2021	Norm*	2020	2019	2021	Norm*	2020	2019	2021	Norm*	2020	2019
Apr	328	357	274	308	---	---	---	---	---	---	---	---
May	671	736	641	593	362	386	333	303	249	282	222	202
June	1107	982	1081	986	754	626	721	630	556	448	536	458
July	1265	1182	1193	1141	894	810	821	769	672	624	625	585
Aug	1151	1119	1097	980	782	747	725	610	573	561	539	444
Sept	895	775	762	788	548	437	434	441	397	320	312	298
Totals	5417	5155	5048	4796	3340	3006	3034	2753	2447	2235	2234	1987

*Normals = 1981-2010 averages

Growing season GDD Totals, Normals, and Killing Frost Dates

Year	Frost Date	Corn Temp (°F)	Total GDD	Frost Date	Sunflower Temp (°F)	Total GDD
2019	Oct 2	32	1987	Oct 10	29	2637
2020	Sept 8	29	2002	Sept 9	27	2496
2021	*Oct 16	32	2566	**Oct 21	22	3321

*Normal Corn GDD for date = 2322 **Normal Sunflower GDD for date = 2947

Total corn GDD = May 1 to frost date Total sunflower GDD = May 20 to frost date

Normals = 1981-2010 averages Source: NDAWN

Agronomic Research Trials

Thank you for taking the time to read through the research and Extension highlights occurring at CREC over the past year. We strive to provide a variety of content to address the many complex challenges faced throughout the ag community. 2021 was very challenging year in ag research and beyond. We are grateful that many successful trials and outreach activities were completed, but certain crops and rotations were not successful this year. The variety trials in this booklet represent the trials with results of integrity, but know that if you do not see a specific long-standing trial it could be a victim of the drought. If trials are severely impacted by drought, the resulting yields can be quite variable and not representative of a treatment or variety when compared to another. As you look through the content and feel that there are things we are missing or want to provide feedback, please contact us at NDSU.Carrington.REC@ndsu.edu or visit our website (https://www.ag.ndsu.edu/CarringtonREC) to find specific individuals. We are happy to help whenever possible.

The following information is a listing of agronomic research conducted at the Carrington Research Extension Center. CREC and other NDSU research staff provide this list to illustrate specific research issues that are being addressed. The listing briefly describes the trial and indicates project collaborators who are working in cooperation with CREC agronomy team leaders. Results of this work may be made available at a later date by contacting the CREC.

Cover Crop

Corn: Corn cover crop grazing experiment; *North Central Region Sustainable Agriculture Research and Education*
Dry Bean: Dry bean cover crop herbicide tolerance; *Northarvest Bean Growers Assoc.*
Dry Bean: Dry bean cover crop termination timing; *Northarvest Bean Growers Assoc.*
Dry bean: Pinto bean with rye cover/companion; *Northarvest Bean Growers Assoc.*
Soybean: Evaluation of rye seeding rate by planting date; *North Dakota Soybean Council*
Soybean: Winter rye cover crop management techniques for soybean - Tri-County (Wishek); *North Dakota Soybean Council*
Wheat: Cover crop timing
Wheat: Legume interseeding

Crop Fertility

Canola: Optimizing nitrogen and sulfur application strategies to improve canola production - Minot; *Eriksmoen (North Central REC)*
Canola: Optimizing nitrogen and sulfur application strategies to improve canola production - dryland
Canola: Optimizing nitrogen and sulfur application strategies to improve canola production - irrigated
Corn: Developing algorithm to predict corn nitrogen response - Fingal
Corn: Developing algorithm to predict corn nitrogen response (2) - Oakes; *Cooper (OIRS)*
Corn: Effects of mycorrhizal depletion on corn after non-mycorrhizal crops (canola, beets and soybean year 1); *North Dakota Corn Utilization Council*
Corn: In-season estimation of N requirment for corn using remote sensors
Corn: In-season estimation of N requirment for corn using remote sensors - Oakes; *Cooper (OIRS)*
Corn: Italpolina corn in-furrow starter comparison (2); *Hello-Nature/Italpollina)*
Corn: Jump starting corn mycorrhizal colonization (corn year 2); *North Dakota Corn Utilization Council*
Corn: PPI phosphorus in corn/soybean rotation; *Bortolon (North Central REC)*
Corn: Phosporus and Zn starter fertilizer; *North Dakota Corn Utilization Council*
Corn: Renuvix polymer-coated urea evaluation in corn; *North Dakota Corn Utilization Council*
Corn: Renuvix polymer-coated urea evaluation in corn - Oakes; *Cooper (OIRS)/North Dakota Corn Utilization Council*
Dry bean: Pinto bean fertilizer; *Northarvest Bean Growers Assoc.*
Soybean: PPI phosphorus in corn/soybean rotation
Wheat: Developing algorithm to predict wheat nitrogen response - New Rockford

Wheat: Developing algorithm to predict wheat nitrogen response - Wishek
Wheat: Phosphorous by zinc antagonism

Crop Management
Barley: Cropping systems experiment - rotation, tillage, and fertility
Corn: Cropping systems experiment - rotation, tillage, and fertility
Dry bean: Pinto bean row spacing and population; *Northarvest Bean Growers Assoc.*
Durum: Durum intensive management
Fababean: Evaluation of yield components of fababean; *Hanson (Langdon REC)/Eriksmoen (North Central REC)/AGRALYTICA - RMA*
Field Pea: Cropping systems experiment - rotation, tillage, and fertility
Field Pea: Field pea protein management
Intercropping: Field pea and canola intercropping planting date
Intercropping: Hemp intercropping options
Intercropping: NDSU trial
Intercropping: Organic wheat/flax densities
Intercropping: Organic wheat/flax variety combinations
Intercropping: Soybean and canola intercropping seeding rates
Intercropping: Winter rye and winter camelina intercrops
Misc: Hail insurance demonstration plots; *Natl. Assoc. of Underwriting Agents*
Soybean: Cropping systems experiment - rotation, tillage, and fertility
Soybean: Soybean and winter rye water use; *North Dakota Soybean Council*
Soybean: Soybean early planting date demonstration; *BASF*
Soybean: Soybean maturity by seeding rate evaluation
Soybean: SHARE farm - tillage and soil health; *Wick (Soil Science)*
Sunflower: Cropping systems experiment - rotation, tillage, and fertility
Sunflower: Row by planting rate demonstration; *Beutow (Dickinson REC)/National Sunflower Assoc.*
Wheat: Cropping systems experiment - rotation, tillage, and fertility
Winter Wheat: Cropping systems experiment - rotation, tillage, and fertility

Crop Quality
Wheat: Dryland zinc fortification
Wheat: Irrigated zinc fortification

Product Evaluation
Canola: Assess efficacy of XiteBio inoculant products; *XiteBio*
Corn: Assessment of enhanced efficiency nitrogen products under irrigation at Oakes; *Cooper (OIRS)*
Field Pea: Assess efficacy of Rizobacter inoculant and fertility products; *Rizobacter*
Field Pea: Assess efficacy of XiteBio inoculant products; *XiteBio*
Field Pea: Evaluation of inoculants in field pea; *BASF*
Lentil: Lentil seed treatment evaluation; *Miller (Montana State Univ.)/Specialty Crop Research Initiative*
Lentil: Lentil special input trial; *Miller (Montana State Univ.)/Specialty Crop Research Initiative*
Misc: Assessment of eNhance as a slow N release multinutrient fertilizer on bare ground; *Agroliquid*
Soybean: Assess efficacy of Rizobacter adjuvant products; *Rizobacter*
Soybean: Assess efficacy of Rizobacter inoculant and fertility products; *Rizobacter*
Soybean: Assess efficacy of XiteBio inoculant products; *XiteBio*
Soybean: Evaluation of inoculants in soybean; *BASF*
Soybean: West Central soybean biological treatments; *West Central*
Soybean: West Central soybean foliar inputs; *West Central*
Soybean: West Central soybean inoculation; *West Central*
Sunflower: Effect of seed coating on stand establishment and yield in confection hyrbids; *Germains*
Sunflower: Effect of seed coating on stand establishment and yield in oil hybrids; *Germains*
Sunflower: Evaluation of plant bio-stimulants for yield enhancement - non-oil hybrids; *Valent BioSciences*

Sunflower: Evaluation of plant bio-stimulants for yield enhancement - oil hybrids; *Valent BioSciences*
Wheat: Evaluation of enhanced efficiency nitrogen fertilizers in wheat; *Koch Ag and Energy LP*
Wheat: Renuvix polymer coated urea applied with the seed in wheat
Wheat: Renuvix polymer coated urea applied with the seed under irrigation in wheat
Wheat: Micronutrient applications in wheat; *West Central*

Plant Pathology
Alfalfa: Alfalfa seed treatment, Rhizoctonia inoculated; *McGregor & Company*
Alfalfa: Fungicide efficacy evaluation; *Corteva*
Black bean: Impact of fungicide application timing - white mold; *USDA Specialty Crop Block Grant Program/Northarvest Bean Growers Assoc.*
Canola: Canola breeding nursery, Sclerotinia resistance screening; *Cibus*
Canola: Fungicide efficacy, canola Sclerotinia and plant health - registered fungicides; *BASF*
Canola: Fungicide efficacy, canola Sclerotinia; *ADAMA*
Canola: Fungicide efficacy, canola Sclerotinia, experimental fungicides, protocol #1; *BASF*
Canola: Fungicide efficacy, canola Sclerotinia, experimental fungicides, protocol #2; *BASF*
Canola: Fungicide efficacy, canola Sclerotinia; *BioSafe*
Chickpea: Chickpea breeding nursery, Ascochyta resistance screening
Chickpea: Fungicide efficacy, Ascochyta blight; *Northern Pulse Growers Assoc./ ND Crop Protection Product Harmonization and Registration Board*
Chickpea: Fungicide efficacy, Ascochyta bligtht; *BASF*
Chickpea: Fungicide efficacy, Ascochyta bligtht; *BioSafe*
Chickpea: Fungicide efficacy, Ascochyta bligtht; *Corteva*
Chickpea: Impact of spray droplet size - TeeJet nozzles; *Northern Pulse Growers Assoc./ND Crop Protection Product Harmonization and Registration Board*
Chickpea: Impact of spray droplet size - Wilger nozzles; *Northern Pulse Growers Assoc./ND Crop Protection Product Harmonization and Registration Board*
Chickpea: Impact of spray volume; *Northern Pulse Growers Assoc./ND Crop Protection Product Harmonization and Registration Board*
Dry bean: Dry bean in-furrow fungicide, Rhizoctonia - fungicide efficacy; *Bayer CropScience*
Dry bean: Dry bean in-furrow fungicide, Rhizoctonia - fungicide rate response; *Bayer CropScience*
Dry bean: Dry bean seed treatment; *Lallemand*
Dry bean: Dry bean seed treatment, Rhizoctonia; *Albaugh LLC*
Dry bean: Dry bean seed treatment, Rhizoctonia; *McGregor & Company*
Dry bean: Dry bean seed treatment, white mold; *McGregor & Company*
Dry bean: Dry bean white mold resistance screening nursery; *Everhart (Univ. of Nebraska, Lincoln)/USDA National Sclerotinia Initiative*
Dry bean: Fungicide efficacy, white mold; *BASF*
Dry bean: Fungicide efficacy, white mold, experimental fungicides; *Bayer CropScience*
Dry bean: Fungicide efficacy, white mold, registered fungicides; *Bayer CropScience*
Dry bean: Fungicide efficacy, white mold; *Gowan USA*
Dry bean: Impact of fungicide spray droplet size; *USDA Specialty Crop Block Grant Program*
Dry bean: Impact of fungicide spray volume; *USDA Specialty Crop Block Grant Program*
Durum: Prosaro Pro management of FHB and leaf diseases in durum.; *Bayer CropScience*
Durum: USWBSI uniform fungicide efficacy trial; *Friskop (Plant Pathology)/U.S. Wheat and Barley Scab Initiative*
Field pea: Field pea powdery mildew disease resistance screening
Field pea: Field pea powdery mildew disease resistance screening - USDA breeding materials
Field pea: Field pea seed treatment, Fusarium inoculated; *Albaugh LLC*
Field pea: Field pea seed treatment, Fusarium inoculated; *Bayer CropScience*
Field pea: Field pea seed treatment, Fusarium inoculated; *Syngenta*
Field pea: Field pea seed treatment, native pathogen pressure; *Bayer CropScience*
Field pea: Field peas, assessment of Rhizobium inoculants; *BASF*
Field pea: Fungicide efficacy, field pea Ascochyta blight; *BASF/Nichino USA*

Kidney bean: Impact of fungicide application timing - white mold; *USDA Specialty Crop Block Grant Program/Northarvest Bean Growers Assoc.*
Lentil: Fungicide efficacy evaluation, lentil anthracnose; *Corteva*
Lentil: Seed treatment evaluation, lentil Fusarium; *Syngenta*
Navy bean: Impact of fungicide application timing - white mold; *USDA Specialty Crop Block Grant Program/Northarvest Bean Growers Assoc.*
Oats: Herbicide safety in oats
Pinto bean: Impact of fungicide application timing - white mold; *USDA Specialty Crop Block Grant Program/Northarvest Bean Growers Association*
Pinto bean: Impact of fungicide application timing - white mold, dryland; *Northarvest Bean Growers Assoc.*
Pinto bean: Impact of fungicide application timing, white mold - Oakes; *USDA Specialty Crop Block Grant Program/Northarvest Bean Growers Assoc.*
Pinto bean: Impact of fungicide spay droplet size, rye (white mold) - Oakes; *USDA Specialty Crop Block Grant Program*
Soybean: Fungicide efficacy, Sclerotinia, experimental fungicides, protocol #1; *BASF*
Soybean: Fungicide efficacy, Sclerotinia, experimental fungicides, protocol #2; *BASF*
Soybean: Fungicide efficacy, Sclerotinia, registered fungicides; *BASF*
Soybean: Fungicide efficacy, Sclerotinia; *Gowan USA*
Soybean: Fungicide efficacy, Sclerotinia; *Syngenta*
Soybean: Impact of fungicide application interval - white mold; *North Dakota Soybean Council*
Sunflower: Impact of bagging heads on head rot development in sunflowers; *USDA Specialty Crop Block Grant Program*
Sunflower: Impact of bee-vectored C. roseae on management of head rot in sunflowers, Carrington; *USDA Specialty Crop Block Grant Program*
Sunflower: Impact of bee-vectored C. roseae on management of head rot in sunflowers, on-farm study (Wells County); *USDA Specialty Crop Block Grant Program*
Sunflower: USDA sunflower head rot resistance screening nursery; *Underwood (USDA)*
Sunflower: USDA stalkrot nursery; *Underwood (USDA)*
Wheat: Evaluation of head scab timing to competitive comparisons; *BASF*
Wheat: Evaluation to define efficacy and rate for control of FHB; *Bayer CropSciences*
Wheat: Prosaro Pro management of ergot and other diseases in wheat; *Bayer CropSciences*
Wheat: Prosaro Pro management of leaf and head diseases in wheat; *Bayer CropSciences*
Wheat: Evaluation of fungal leaf spot management and propiconazole sensitivity; *Friskop (Plant Pathology)*
Wheat: Foliar fungicide evaluation - Wishek
Wheat: USWBSI integrated scab fungicide management trial; *Friskop (Plant Pathology)/U.S. Wheat and Barley Scab Initiative*
Wheat: Wheat seed treatment, common root rot; *BASF*
Wheat: Wheat seed treatment, efficacy of biological seed treatments; *BASF*
Wheat: Wheat seed treatment, Fusarium inoculated; *BASF*
Wheat: Wheat seed treatment, hybrid wheat; *BASF*
Wheat: Wheat seed treatment, common root rot; *Bayer CropScience*

Seed Increase
Buckwheat: Experimental increase

Germplasm Evaluation/Cultivar Development
Barley: Barley breeder nursery; *Horsley (Plant Sciences)*
Barley: Barnes County (Dazey) variety trial
Barley: Drill strip demonstration plots
Barley: Dryland variety trial
Barley: Irrigated variety trial
Barley: No-till variety trial

Barley: Organic variety trial
Barley: Tri-County (Wishek) variety trial
Buckwheat: Conventional variety trial
Buckwheat: Industry nursery; *MinnDak Growers*
Buckwheat: Organic variety trial
Canola: Canola breeder nursery; *Rahman (Plant Sciences)*
Canola: Canola hybrid tolerance to salinity; *Croplan/Winfield*
Canola: Conventional canola performance test; *Industry*
Canola: Liberty Link performance test; *Industry*
Canola: Roundup Ready performance test; *Industry*
Corn: Corn 60" hyrid performance evaluation; *Cooper (OIRS)*
Corn: Dryland corn silage performance test; *Industry*
Corn: Dryland hybrid performance test; *Industry*
Corn: Dryland hybrid performance test - conventional lines; *Industry*
Corn: Fingal hybrid performance test; *Industry*
Corn: Irrigated corn silage performance test; *Industry*
Corn: Irrigated hybrid performance test; *Industry*
Corn: Oakes dryland hybrid performance test; *Industry*
Corn: Oakes irrigated hybrid performance test; *Industry*
Corn: Organic corn breeder nursery; *Goldstein (Mandaamin Institute)*
Dry Bean: Dry bean breeder nursery; *Osorno (Plant Sciences)*
Dry Bean: Dryland variety trial; *Industry*
Dry Bean: Irrigated variety trial; *Industry*
Dry Bean: Tri-County (Wishek) variety trial
Durum: Drill strip demonstration plots
Durum: Dryland variety trial
Durum: No-till variety trial
Durum: Organic variety trial
Durum: Uniform Regional Durum Nursery - dryland; *Elias (Plant Sciences)*
Durum: Uniform Regional Durum Nursery - irrigated; *Elias (Plant Sciences)*
Einkorn: Organic variety trial
Emmer: Organic variety trial
Field Pea: Breeder nursery - advanced yield trial; *Nonoy (Plant Sciences)/Worral (North Central REC)*
Field Pea: Field pea variety evaluation; *Equinom*
Field Pea: Field pea variety evaluation; *Limagrain*
Field Pea: Organic variety trial
Field Pea: Organic winter pea nursery
Field Pea: Field pea variety evaluation; *Pulse USA*
Field Pea: Variety trial - primary statewide evaluation; *Nonoy (Plant Sciences)/Worral (North Central REC)*
Flax: Organic variety trial
Flax: Variety trial
Flax: Breeder nursery; *Rahman (Plant Sciences)*
Forages: Forage oat variety trial
Forages: Forage pea variety trial; *Industry*
Forages: Wishek cool-season forage evaluation; *Sedevic (Central Grasslands REC)*
Forages: Wishek warm-season forage evaluation; *Sedevic (Central Grasslands REC)*
Hemp: Dryland variety trial; *Hanson (Langdon REC)/Industry*
Kernza: Kernza demonstration plot
Lentil: Breeder nursery - advanced yield trial; *Nonoy (Plant Sciences)/Worral (North Central REC)*
Lentil: Organic variety trial
Lentil: Lentil germplasm screening; *Miller (Montana State Univ./Specialty Crop Research Initiative*
Lupin: Evaluation of advanced lupin selections
Lupin: Lupin drill strip increases

Lupin: Lupin variety evaluation
Oats: Drill strip demonstration plots
Oats: Dryland variety trial
Oats: Oat breeder nursery; *McMullen (Plant Sciences)*
Oats: Organic breeder nursery; *Nilsen (Agri Food Canada)*
Oats: Organic breeder nursery *Caffe-Treml (South Dakota State Univ.)*
Oats: Organic hexaploid yield trial; *Richter (General Mills)*
Oats: Organic rust sentinel evaluation; *Richter (General Mills)*
Oats: Organic variety trial
Rye: Dryland variety trial
Rye: Organic variety trial
Sorghum: Forage sorghum nursery
Sorghum: Grain sorghum nursery
Soybean: Barnes County (Dazey) conventional variety performance test; *Industry*
Soybean: Barnes County (Dazey) Roundup Ready variety performance test; *Industry*
Soybean: Breeder Nursery: 21 Expt.19 - Irrigated; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.20 - Irrigated; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.21 - Irrigated; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.23 - Irrigated; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.24 - Irrigated; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.13 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.19 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.20 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.21 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.22 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.23 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.24 - Dryland; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.20 - Dazey; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.21 - Dazey; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.22 - Dazey; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.23 - Fingal; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.24 - Fingal; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.20 - Wishek; *Miranda (Plant Sciences)*
Soybean: Breeder Nursery: 21 Expt.24 - Wishek; *Miranda (Plant Sciences)*
Soybean: Dryland conventional performance test; *Industry*
Soybean: Dryland Roundup Ready variety performance test; *Industry*
Soybean: Dryland soybean agronomic performance trial - Carrington; *BASF*
Soybean: Dryland soybean agronomic performance trial - Oakes; *BASF*
Soybean: Irrigated conventional variety performance test; *Industry*
Soybean: Irrigated Roundup Ready variety performance test; *Industry*
Soybean: Irrigated soybean agronomic performance trial - Carrington; *BASF*
Soybean: Irrigated soybean agronomic performance trial - Oakes; *BASF*
Soybean: LaMoure conventional variety performance test; *Industry*
Soybean: LaMoure Roundup Ready variety performance test; *Industry*
Soybean: Oakes conventional variety performance test; *Industry*
Soybean: Oakes irrigated Roundup Ready variety performance test; *Industry*
Soybean: Organic variety trial
Soybean: Soybean agronomic performance trial - Barnes County (Dazey); *BASF*
Soybean: Soybean agronomic performance trial - Fingal; *BASF*
Soybean: Soybean agronomic performance trial - Tri-County (Wishek); *BASF*
Soybean: Tri-County (Wishek) conventional variety performance test; *Industry*
Soybean: Tri-County (Wishek) Roundup Ready variety performance test; *Industry*
Spelt: Organic variety trial
Sunflower: Non-oil sunflower hybrid performance test; *Industry*

Sunflower: Oil sunflower hybrid performance test; *Industry*
Sunflower: Sunflower hybrid nursery; *SunOpta*
Sunflower: Sunflower hybrid tolerance to salinity; *Croplan/Winfield*
Winter Wheat: Elite breeder's nursery; *Marais (Plant Sciences)*
Winter Wheat: Dryland variety trial
Wheat: Barnes County (Dazey) variety trial
Wheat: Drill strip demonstration plots
Wheat: Dryland variety trial
Wheat: Irrigated variety trial
Wheat: No-till variety trial
Wheat: Organic variety trial
Wheat: Spring wheat breeder nursery; *Green (Plant Sciences)*
Wheat: Spring wheat salt tolerant germplasm selection; *Green (Plant Sciences)*
Wheat: Tri-County (Wishek) variety trial
Wheat: Uniform Regional Spring Wheat Nursery; *Garvin (USDA)*
Wheat: Wheat variety tolerance to salinity; *Croplan/Winfield*

Weed Science

Corn: Corn herbicide by cover crop evaluation; *Ikley (Plant Sciences)*
Dry Bean: Pinto bean response to low-rate preplant dicamba; *Ikley (Plant Sciences)/Jenks (North Central REC)/North Dakota Soybean Council*
Flax: Flax tolerance to PRE herbicides - dryland; *Jenks (North Central REC)/Ameriflax*
Flax: Flax tolerance to PRE herbicides - irrigated; *Jenks (North Central REC)/Ameriflax*
Hemp: Hemp herbicide tolerance evaluation; *ND Crop Protection Product Harmonization and Registration Board*
Lentil: Lentil herbicide tolerance screening; *Gowan*
Misc: Herbicide site of action demonstration
Misc: Weed resistance screening through remote sensing; *Sun (Ag and Biosystems Engineering)*
Misc: Valent: evaluation of herbicide plant-back intervals; *Valent*
Misc: Vida burndown evaluation; *Gowan*
Soybean: Response to low-rate preplant dicamba; *Ikley (Plant Sciences)/Jenks (North Central REC)/North Dakota Soybean Council*
Soybean: Burndown options for soybeans; *BASF*
Sunflower: Response to low-rate preplant dicamba; *Ikley (Plant Sciences)/Jenks (North Central REC)/North Dakota Soybean Council*
Wheat: Far-Go residue management; *Gowan*
Wheat: Triallate formulation evaluation; *Gowan*
Wheat: Evaluation of grass control options in wheat; *UPL*
Wheat: Weed control with Varro + Starane; *Bayer CropSciences*

NDSU Carrington Research Extension Center Staff

Experiment Station

Mike Ostlie	Agronomist/Asst. Director
Michael Wunsch	Plant Pathologist
Jasper Teboh	Soil Scientist
Colin Tobin	Animal Scientist
David Kramar	Precision Ag Specialist
Steve Zwinger	Research Specialist/Agronomy
Dave Copenhaver	Research Specialist/Seedstocks
Ezra Aberle	Research Specialist/Agronomy
Szilvia Yuja	Research Specialist/Soils
Suanne Kallis	Research Specialist/Pathology
Jesse Hafner	Research Specialist/Pathology
Tim Indergaard	Research Technician/Agronomy
Todd Ingebretson	Research Technician/Agronomy
Rick Richter	Research Technician/Seedstocks
Tim Schroeder	Research Technician/Livestock
Steve Schaubert	Research Technician/Agronomy
Scott Fetch	Research Technician/Seedstocks
Chad Richter	Research Technician/Seedstocks
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Harley Burgard	Research Technician/Agronomy
Kathy Wiederholt	Fruit Project Manager
Melissa Hafner	Laboratory Manager
Xavier Klocke	Research Technician/Pathology
Mark Halvorson	Seasonal Research Assistant
Sam Richter	Seasonal Research Assistant
Myrna Friedt	Administrative Assistant
Joan Copenhaver	Part-time Administrative
Sabrina Cunningham	Part-time Administrative
Kalie Anderson	Part-time Program Assist.
Vern Anderson	Animal Scientist - Emeritus
Tami Snow	Part-time Custodian/Grounds

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Greg Endres	Cropping Systems Specialist
Karl Hoppe	Livestock Systems Specialist
Mary Keena	Environmental Management
David Kramar	Precision Ag Specialist
Linda Schuster	Administrative Secretary

North Dakota Forest Service

Gerri Makay	Community Forestry Specialist

North Dakota Farm Business Management Education Program

Jason Fewell	Instructor/Coordinator
Steve Metzger	Instructor - Retired

Oakes Irrigation Research Site

Kelly Cooper	Research Agronomist
Seth Nelson	Research Specialist/Agronomy
Heidi Eslinger	Research Technician

Throughout the year, the Center hires individuals on a part-time basis to help in the research effort. Many of these are students and local residents. We would like to acknowledge the following who helped at some time during the year: Emma Aberle, Hunter Beumer, Holly Cunningham, Cayler Ellingson, Spencer Eslinger, Sierra Friedt, Sydney Friedt, Callen Garber, Christine Halvorson, Tessa Hartl, Regan Hartwig, Gabriela Henson, Carsyn Hilbert, Coltyn Hilbert, Alexa Holth, Emma Janz, Justyne Klocke, Auna Kubal, Marlys Lange, Elizabeth Lee, Karlee Lesmann, Natasha Lesmann, Norton Levis, Baylee Lura, Lea Mittleider, Betty Montgomery, Jonathan Murphy, Aaron Neumiller, Austin Neumiller, Carrie Nichols, Wayde Pickinpaugh, Gabe Ricter, Alexis Rushlow, Travis Scanson, Tyler Scanson, Blaine G. Schatz, Cole Seaburg, Jacob Seaburg, Kaitlyn Thompson, Emily Tjelta, Alexis Wells, and Kayden Wiedrich.

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