

# MCCC-NORTH DAKOTA ANNUAL REPORT

**April 2020 to March 2021**

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## COMPLETED RESEARCH

### 1. Soybean cyst nematode and cover crops. (Guiping Yan and Krishna Acharya)

Industrial oilseeds have a great potential in the northern Great Plains both as oilseeds and as cover crops sown following wheat (*Triticum aestivum* L.) harvest and before soybean [*Glycine max* (L.) Merr.] sowing in the following spring. One of the most important biotic stresses in soybean production is soybean cyst nematode (*Heterodera glycines* Ichinohe, SCN), a serious pest that affects 90% of the soybean producing areas in the U.S. The objective of this study was to evaluate the host status of and the SCN population reduction by, winter camelina [*Camelina sativa* (L.) Crantz, cv. Joelle], crambe (*Crambe abyssinica* Hochst. Ex R.E.Fr., cv. BelAnn), and brown mustard (*Brassica juncea* L. cv. Kodiak). The experiments were performed in a growth chamber at 27<sup>0</sup> C for 35 days by planting the crops in soil naturally infested with SCN and autoclaved sandy soil artificially inoculated with two SCN populations from two fields in North Dakota. Soybean cyst nematode did not reproduce on brown mustard or camelina with a female index (FI) of 0, suggesting these are non-hosts, while it reproduced on crambe. The numbers of white females on crambe ranged from 1 to 13 per plant with FI of 0.2 to 1.1 in naturally infested soils, and 1 to 4 per plant with FI of 1.2 to 2.5 in artificially infested soils, thus crambe would be classified as a poor-host (FI < 10). Brown mustard and winter camelina reduced the SCN populations by an average of 51% and 48%, respectively, while crambe only reduced the populations by an average of 24%, across all the experiments with naturally infested soils when compared with the initial population levels. Both brown mustard and camelina consistently reduced the SCN populations but crambe did not steadily reduce the SCN populations when compared with the non-planted control (fallow).

SCN reproduces on a wide range of plants, including some cover crops. However, reproduction of SCN populations on a number of cover crops has not been investigated in the northern Great Plains. Thirty-five cover crop species/cultivars from four plant families were evaluated as hosts for SCN. Greenhouse evaluations were done with two common SCN populations, SCN103 (HG type 0) and SCN2W (HG type 7) under controlled conditions. The sources of two SCN populations were two soybean fields of North Dakota. After 35 days of growth, white SCN females were extracted from individual plants and counted to determine a female index (FI = average number of females on a tested crop/average number of females in a susceptible check x 100) for each crop. Out of the 35 cover crop species/cultivars tested, at least one of the SCN populations reproduced on seven crops/cultivars but did not reproduce on the other 28 crops/cultivars. Out of these seven crops, only white lupine (*Lupinus albus* L.) was a suitable host (FI ≥ 10) for both SCN populations in all the experiments, while others showed varied responses from poor host to suitable host for the SCN populations. The host crops were from the family *Brassicaceae* or *Fabaceae*, while all the crops in the *Linaceae* or *Poaceae* family were non-hosts. The non-host crops can be planted in SCN-infested fields without the concern of increasing SCN populations, while poor hosts with low female index should be evaluated for effects on reduction of SCN numbers in the fields before they are used as cover crops in a soybean cropping system.

Microplot experiments were conducted to evaluate the effects of cover crops on population reduction of SCN in 2016 and 2017. Ten crop species, including annual ryegrass (*Lolium multiflorum* L.), Austrian winter pea (*Pisum sativum* L. *subsp.* *arvense*), carinata (*Brassica carinata* A. Braun), faba bean (*Vicia faba* Roth), foxtail millet [*Setaria italica* (L.) P. Beauvois], daikon radish (*Raphanus sativus* L.), red clover (*Trifolium pratense* L.), sweetclover (*Melilotus officinalis* L.), turnip (*Brassica rapa subsp. rapa* L.), and winter rye (*Secale cereale* L.) were

planted along with susceptible soybean [*Glycine max* (L.) Merr., cv. Barnes] in soil naturally infested with each of two SCN populations (SCN103 and SCN2W) from two North Dakota soybean fields. Crops were grown in large plastic pots for 75 days in an outdoor environment (Microplot). Soil samples were collected from each pot for nematode extraction and SCN eggs were counted to determine the final SCN egg density. The population reduction was determined for each crop, and non-planted natural soil (fallow). All the tested crops and non-planted natural soil had significantly ( $P < 0.0001$ ) lower final population densities compared to susceptible soybean (Barnes). In addition, a significant difference ( $P < 0.0001$ ) was observed between the SCN population suppressions caused by cover crops versus the fallow treatment. All cover crops except Austrian winter pea, carinata, faba bean, and foxtail millet had consistently lower SCN egg numbers than in fallow in both years of the experiments. The average population reductions of SCN by the cover crops ranged from 44 to 67% in comparison with the initial population density, while the fallow had natural reductions from 4 to 24%. Annual ryegrass and daikon radish reduced SCN egg numbers to a greater extent than the other cover crops, with an average of 65 and 67% reduction of initial population density, respectively from two years. The results suggested that cover crops reduced the SCN populations in external microplot conditions, and their use has great potential for improving SCN management in infested fields.

## Research in Progress

### **1. Biomass yield and quality of annual forage mixtures compared with sorghum monocrops (*Kenneth Mozea and Marisol Berti*)**

Annual forage mixtures are a good source of forage with high nutritional value for ruminant consumption. Determining what forage mixture to use for ruminant grazing is important. Treatment 7 (a mixture of oat, phacelia, faba bean, pea, and Brachytic sorghum) had the highest biomass yield of 0.8 tons/acre. No difference ( $P > 0.05$ ) in forage yield was found between the monocrops and mixtures, excluding a late-planted brassica mix.

Sorghum x sudan monocrop had the highest total digestible nutrients (TDN) at 43%, and differences ( $P \leq 0.05$ ) in TDN were observed between the monocrops (Treatments 8 – 12) and mixtures (Treatments 1-7). Crude protein ranged from 9 to 17% in the mixtures and 14 to 18% in monocrops. Acid detergent lignin was less than 7% in all the treatments.

**Methodology**

The study was a randomized complete block design conducted at the Central Grasslands Research Extension Center near Streeter, N.D. (Figure 1). The soil type was Hecla-Ulen loamy fine sands with low water storage and 0-6% slope (USDA, NRCS, 2020). Rainfall was below average through the duration of the study in 2020, except in August (Table 1).



**Figure 1.** Annual forage mixture at the Central Grasslands Research Extension Center near Streeter, N.D.

**Table 1.** Rainfall and average temperature between May and August, 2020 at Central Grasslands Research Extension Center near Streeter, N.D. (NDAWN, 2020).

Month	Mean temperature	Soil temperature	Total rainfall	Departure from normal total rainfall
	-----°F-----		-----inches-----	
<b>May</b>	50.98	49.47	1.81	-0.64
<b>June</b>	67.43	66.19	1.35	-2.06
<b>July</b>	71.23	73.84	2.13	-1.07
<b>August</b>	68.65	71.44	2.73	0.42

The experiment was planted May 19, 2020 using an 8-cone continuous plot drill with row spacing of 6 inches for mixture treatments and 12 inches for monocultures. Experimental areas have been in no-till for five years or more. All plots were fertilized with 71 lbs N/acre and 89 lbs P<sub>2</sub>O<sub>5</sub>/acre before seeding.

Seventeen forage species ranging from cool-season and warm-season varieties, and brassicas were used to develop 12 annual forage treatments (Table 2). Seven treatments (Treatments 1 - 7) were mixtures and five treatments (Treatments 8 – 12) were monocrops. The majority of the experiment was impacted by invasive weeds and ground squirrels, impacting forage production.

Hand weeding was done on June 2, June 16, June 24, and August 13, 2020. Harvest date was August 19, 2020. Plots were harvested with a flail forage harvester; the wet weight was recorded and a sample was taken to determine moisture. The fresh sample was dried and after was dry the % of dry weight was calculated to calculate the dry weight of the total plot.

Nutritional analysis of samples was conducted at the North Dakota State University Nutrition Lab using AOAC standards (AOAC, 2019). The wet chemistry data was calibrated for biomass mixtures using a near-infrared (NIR) spectroscopy equipment. Total digestible nutrients (TDN) were determined using the formula developed by (NRC, 2001):

$$\text{TDN}=[(\text{NFC} \times 0.98) + (\text{CP} \times 0.93) + (\text{FA} \times 0.97 \times 2.25) + (\text{NDF} \times (\text{NDFD}/100)-7)]$$

where, the parameters were non-fiber carbohydrate (NFC), crude protein (CP), fatty acid (FA), neutral detergent fiber (NDF), and neutral detergent fiber digestibility (NDFD).

The design was a randomized complete block design with four replicates. Data analyzed used a general linear model in SAS (SAS version 9.4; SAS Inst. Inc., Cary, N.C.) (Duncan, 1955).

Means were separated using the least significant differences (LSD) at 5% significance

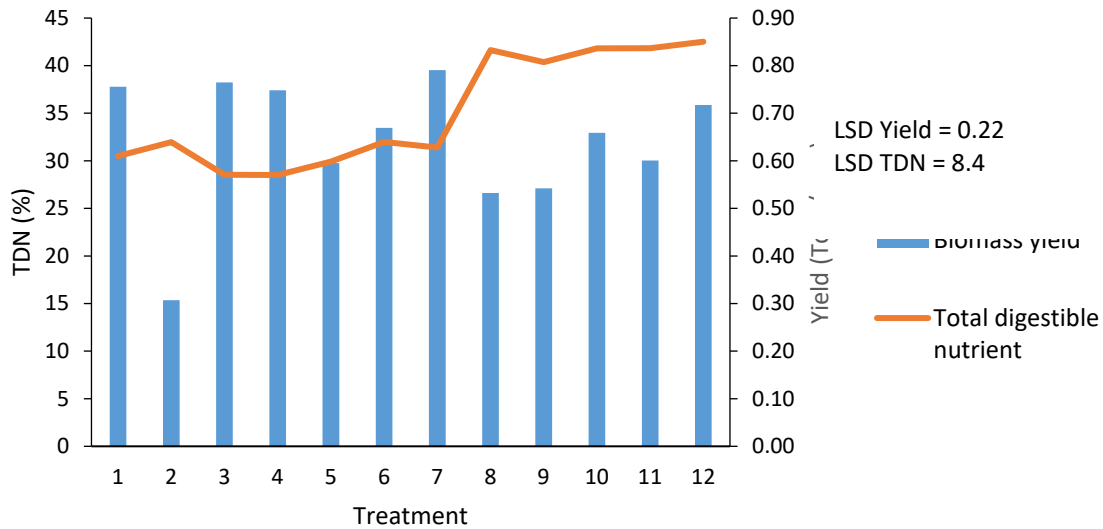
## Results

Treatment 7 had the highest biomass yield of 0.8 tons/acre (Figure 2). Treatment 2 biomass yield was lower than all other treatments ( $P \leq 0.05$ ). However, no difference ( $P > 0.05$ ) in yield was found between the monocrops and mixtures (Figure 2). The TDN contents of monocrops (Treatments 8 – 12) were statistically higher ( $P \leq 0.05$ ) than those of the mixtures (Treatments 1-7). Sorghum x sudan monocrop (Treatment 12) had the highest TDN at 43% (Figure 2). The highest CP content was 18% (Treatment 2 and 10) and lowest just under 10% (Treatment 1) (Figure 3). No difference ( $P > 0.05$ ) was found among treatments 2, 4, 6, 8, 10, 11, and 12 in CP (Figure 3). Acid detergent lignin was less than 7% in all the treatments (Figure 3).

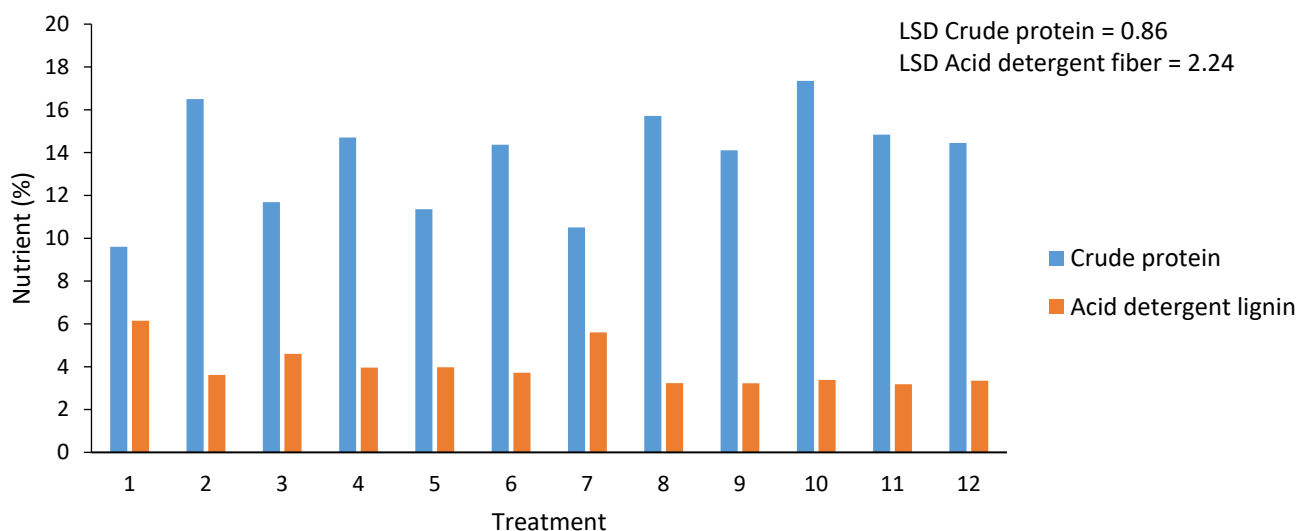
**Table 2.** Seeding rate of annual forage mixtures.

Treatment	Crop	Cultivar	Seeding rate lbs/acre
1	Annual ryegrass	Crusader	12
	Chicory	Choice	2
	Plantain	Tonic	3
	Red clover	Relish	3
2	Hybrid brassica	Winfred	2
	Turnip	New York	2
3	Hybrid brassica	Winfred	2
	Oat	Paul	5
	Forage pea	Arvika	5
	Forage sorghum blend	Pampa Legion	2
	Foxtail millet	Siberian	2
4	Turnip	New York	1
	Forage sorghum blend	Pampa Tribuno	2
	Forage pea	Arvika	5
	Hybrid brassica	Winfred	1
	Oat	Paul	2
	Faba bean	Sampo	2
	Forage pearl millet	Pampa mijo II BMR6	2
5	Forage pearl millet	Pampa mijo II BMR6	5
	Hybrid brassica	Winfred	2

6	Sorghum x sudan Radish	ADSGS6504 Graza	2 2
7	Oat Phacelia Forage pea Faba bean Brachytic sorghum BMR	Paul VNS Arvika Sampo AF7101	5 1 5 5 3
8	Forage sorghum blend	Pampa Legion	10
9	Forage pearl millet	Pampa mijo II BMR6	10
10	Pearl millet	Platino non-BMR	10
11	Brachytic sorghum BMR	AF7101	10
12	Sorghum x sudan	ADSGS6504	10



**Figure 2.** Total digestible nutrients (TDN) and biomass yield of the 12 treatments at the Central Grasslands Research Extension Center in 2020.



**Figure 3.** Acid detergent lignin and crude protein of the 12 treatments at the Central Grasslands Research Extension Center in 2020.

**2. Seeding cover crops after spring wheat harvest, Fargo 2020. (Joel Ransom, Hans Kandel)**

The objective of this study was to evaluate cover and biomass produced for several cover crops when seeded into wheat stubble and allowing spring wheat volunteers to germinate.

**Table 3.** Cover crops, seeding rate and type used during 2020.

Cover crop	Seeding rate Pound per acre	Type
Canola	6	annual cool-season
]Soybean	150,000 live seeds/a	annual warm-season
Forage pea	60	annual cool-season
Soybean/Cowpea	60/30%	annual war- season
Rye	60	winter annual
Cowpea	60	annual warm-season
Camelina	5	winter annual

The previous crop, hard red spring wheat, was harvested on August 4. The cover crops were seeded with a no-till drill with seven rows and row spacing of 7 inch, on August 12, 2020 near Fargo, North Dakota. The soil type is a Fargo-Ryan clay. Spring wheat volunteers were allowed to continue growing.



**Figure 4.** No-till seeding cover crops into wheat stubble, Fargo August 12, 2020.

**Table 4.** Cover crop ground cover, above ground biomass, volunteer wheat biomass and total above ground biomass, Fargo, ND, 2020.

Name	Crop	Canopeo cover %		Cover crop lbs/a		volunteer wheat lbs/a	Total cover lbs/a	
DKL 30-20	Canola	88.7	a <sup>1</sup>	1163	a	122	1284	a
AG08X0	Soybean	51.8	c	51	c	134	185	c
4010	Forage pea	91.6	a	1081	a	81	1161	a
Cowpea entry 3 PI 293499	Soybean/Cowpea	56.2	bc	49	c	182	231	c
Dylan	Rye	76.3	ab	642	b	118	760	b
Cowpea entry 3 PI 293499	Cowpea	59.7	bc	12	c	117	130	c
Joelle	Camelina	86.8	a					
	<i>P</i> value	0.009		<0.001		0.420	<0.001	
	CV	22.6		45.3		50.9	42.0	
	LSD 0.05	24		341		NS	396	

<sup>1</sup>Within a column, means followed by the same letter are not significantly different at  $p \leq 0.05$ .





Soybean and cowpea germinated well but were killed on Sept 9. The total cover percent of soybean, cowpea and the mixture was of the volunteer wheat. The cover crop biomass of soybean and cowpea represents the dead plant tissue remaining after the frost (Table 2). The most cover was obtained with the forage pea and volunteer spring wheat mixture. The largest total cover crop above ground biomass was achieved the canola and spring wheat volunteer mixture. Winter rye resulted in lower end of the season biomass compared with canola and field pea. However, winter rye and camelina will be able to survive the winter and start regrowth in the spring. None of the other cover crops will survive the winter.

**Figure 5.** Cowpea growth one week after seeding.

### 3. Grazing Management Practices to Enhance Soil Health in the Northern Great Plains (*Erin Gaugler, Miranda Meehan and Kevin Sedivec*)

Report from this research is attached at the end of this document.

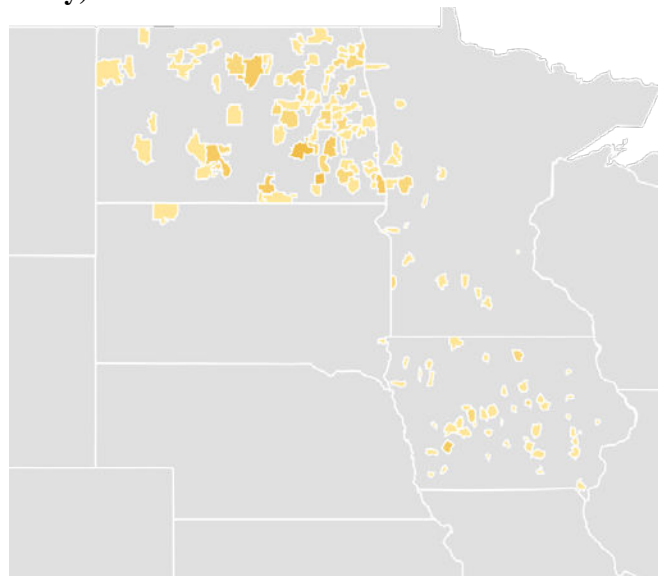
#### EXTENSION EVALUATION AND IMPACT (*Jean Haley*)

From the project states, most respondents (115 – 63% of total) came from North Dakota, followed by Iowa (50 – 27% of total). Minnesota had the fewest respondents (19 – 10% of total). Farmers made up nearly three quarters of the respondents; 42% farm without livestock and 31% farm with livestock.

Ninety-three percent (93%) of grower respondents represent 257,600 acres of farmland across the three participating states. As expected, more acres are leased than owned.

Eighty-two percent (82%) of consultant respondents cover 760,000 acres across the three states. Median acres covered by consultant respondents was 30,000 acres.

It is very important to include consultants in outreach events. While the desired outcome is for growers to adopt practices, consultants have the potential to impact far more acres than individual growers (nearly 3x using these numbers).



**Figure 6.** Survey results, respondents by zip code.

### In-person program participation

Nearly all respondents (97%) attended at least one in-person event between 2016 and 2019. This is not a surprise given the sources used for recruiting respondents – mostly mailing lists gathered at Extension and outreach events. The most common events attended were field days – 78% respondents attended at least one field day during the project period. Almost all the growers attended at least 1 in-person event from 2016 to 2019. Of the in-person events, field days were the most popular with almost three-quarters of the respondents attending (73%).

Like the growers, most consultant respondents attended at least on in-person event between 2016 and 2019. Unlike growers, consultant respondents attended conferences most (82%). The differences between grower and consultant respondents’ in-person event attendance is similar, except for conferences where 26% more consultant respondents attend.

### Cover crops greatest impacts

These six practices represent the greatest impact on grower respondents since 2016. The igreatest of these is evaluating soil health on your fields (35% started after 2016), followed closely by using cover crops to manage weeds, insects, and diseases (34% started after 2016) (Fig. 7). More than three quarters of the grower respondents establish a cover crop after harvest of a cash crop (50% prior to 2016 and 28% since 2016).

N = 165-167 respondents

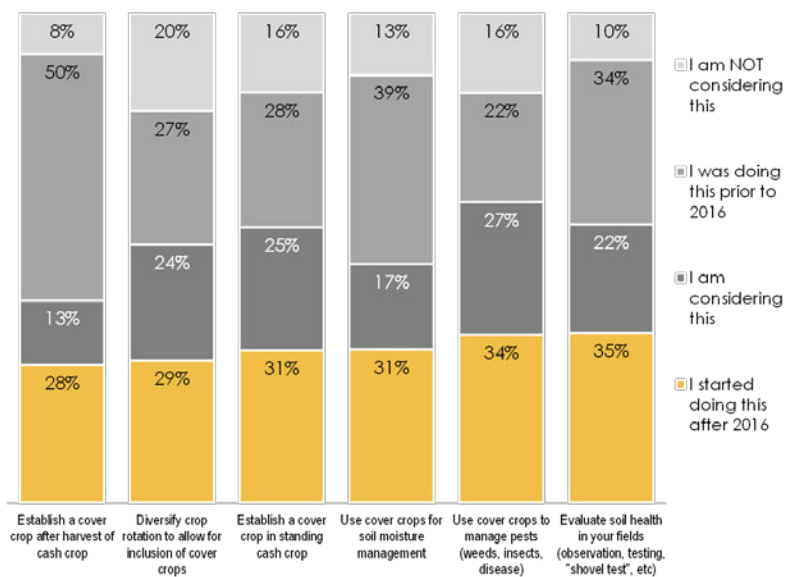


Figure 7. Cover crops practices with greatest impacts

### Cover crop practices with medium impact

Growers seem to have a handle on using cover crops for erosion control – 60% were doing this prior to 2016 and 22% started after 2016. There appears to be some resistance to using aerial seeding with more than a third not considering the practice (36%) (Figure 8).

N = 165-167 respondents

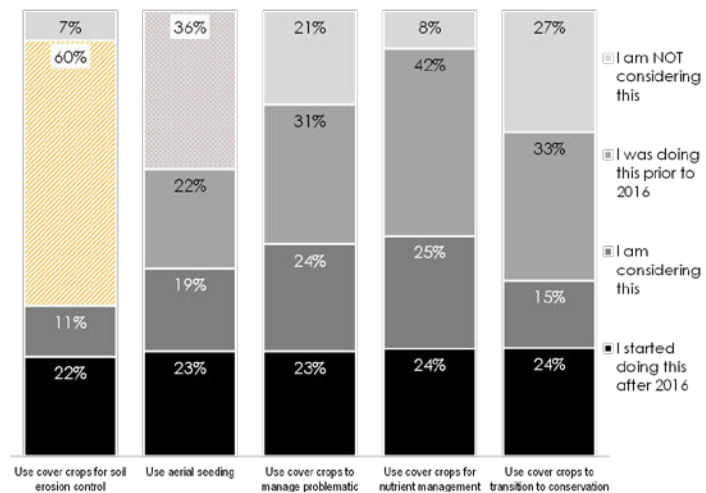


Figure 8. Cover crop practices with medium impact

### Cover crops workshop impact evaluation

**Knowledge changes:** On a scale from none (0) to very high (4), participants gained the greatest knowledge about seed regulations with a change from low (before) to high (after) the workshop. All but one session saw an increase in knowledge; participants already had a high knowledge of

federal programs prior to the workshop, and that did not change (Figure 9).

Workshop resources & tools:

Two-thirds (66%) of respondents are planning to use the Cover Crop Cost Calculator in their work and/or Extension outreach programming. Fewer are planning to use the Cover Crop Kits & Cover Crop Identification Activity, but nearly half are considering this.

More than half the respondents plan to cover Selecting Mixes for Livestock Forage (60%) and Selecting Cover Crops by Function (54%) in their Extension outreach. The greatest potential for impact are covering the topics of Seed Regulations (43% considering) and Cover Variety vs. Selection (49% considering). Seed Regulations received the highest percentage of those not planning to cover this (37%). This is an area, which needs continued work (Figure 10).

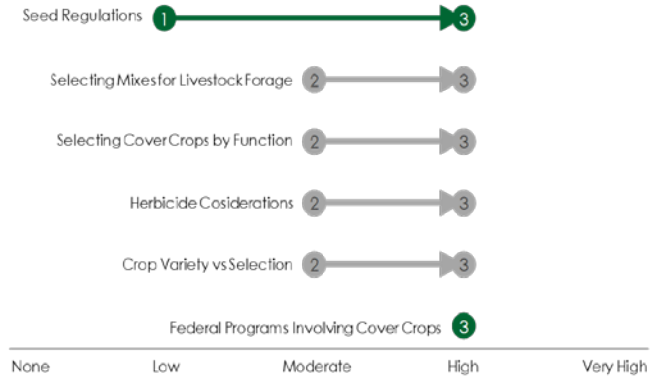


Figure 9. Cover crops workshop impact in knowledge.

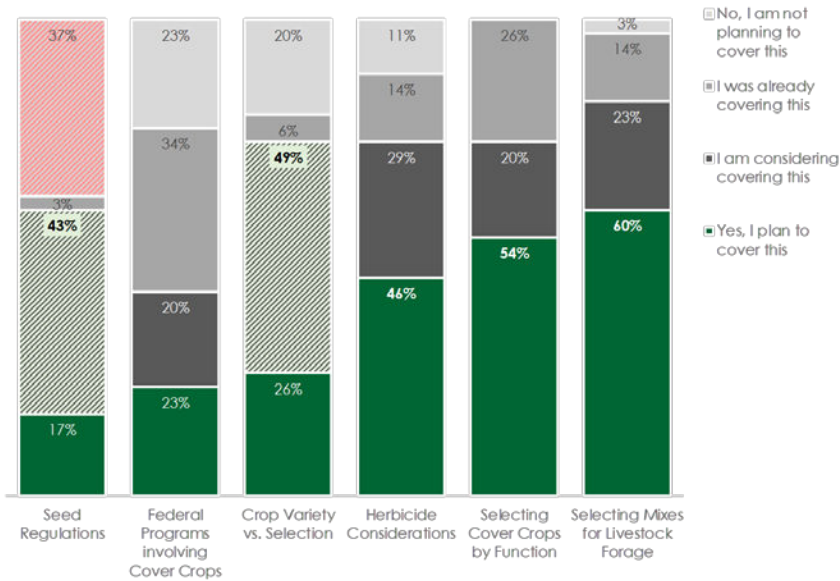


Figure 10. Areas of impact in the cover crops workshop.

## PUBLICATIONS

### Refereed Journal Articles:

1. Schmitt, M. M.T. Berti, D. Samarappuli, and J. Ransom. 2021. Factors affecting the establishment and growth of cover crops intersown into maize (*Zea mays* L.). *Agronomy Accepted*
2. Lukaschewsky, J., D.P. Samarappuli, and M.T. Berti. 2021. Intercropping alfalfa into silage maize can be more profitable than maize silage followed by spring-seeded alfalfa. *Agronomy Accepted*
3. Johnson, K., H. Kandel, D.P. Samarappuli, and M.T. Berti. 2021. Interseeding camelina and rye in soybean with varying maturity provides soil cover without affecting soybean yield. *Agronomy* 11, 353. <https://doi.org/10.3390/agronomy11020353>
4. Sigdel, S., A. Chatterjee, M.T. Berti, C. Gasch, and A. Wick. 2021. Interseeding cover crops in sugarbeet. *Field Crops Res.* 263: 1080709, doi.org/10.1016/j.fcr.2021.108079
5. Cecchin, A., Pourhashem, G., R.W. Gesch, A.W. Lenssen, S. Patel, and M.T. Berti. 2021. The environmental impact of ecological intensification of a cropping system in the U.S. Upper Midwest. *Sustainability* 13: 1696. <https://doi.org/10.3390/su13041696>
6. Cecchin, A., Pourhashem, G., R.W. Gesch, A.W. Lenssen, S. Patel, and M.T. Berti. 2021. Environmental trade-offs of relay-cropping winter cover crops within maize and soybean. *Agric. Systems* 189:103062
7. Patel, S., A.W. Lenssen, K.J. Moore, Y.A. Mohammed, R.W. Gesch, M.S. Wells, B.L. Johnson, M.T. Berti, and H.L. Matthees. 2021. Interseeded pennycress and camelina yield and their influence on row crops. *Agronomy J.* doi: 10.1002/agj2.20655
8. Wittenberg, A., J.V. Anderson, M.T. Berti. 2020. Crop growth and productivity of winter camelina in response to sowing date. *Ind. Crops Prod.* 158:113036 doi.org/10.1016/j.indcrop.2020.113036
9. Forcella, F., S. Patel, A.W. Lenssen, C. Hoening, J. Eckberg, M.S. Wells, R.W. Gesch, and M.T. Berti. 2020. Pollinator visitation of flowering winter oilseeds (field pennycress and winter camelina). *J. Applied Entomology* 00:1-9 doi: 10.1111/jen.12854
10. Mohammed, Y.A., S. Patel, H. Matthees, A.W. Lenssen, B.L. Johnson, M.S. Wells, F. Forcella, M.T. Berti, R.W. Gesch. 2020 Soil nitrogen in response to interseeded cover crops in maize–soybean Production Systems. *Agronomy* 10, 1439; doi:10.3390/agronomy10091439
11. Podder, S., D. Samarappuli, James V. Anderson, and M.T. Berti. 2020. Phenotyping a diverse collection of forage sorghum genotypes for chilling tolerance. *Agronomy*, 10:1074 doi:10.3390/agronomy10081074
12. Acharya, K., Yan, G. P., and Plaisance, A. 2020. Effects of cover crops on population reduction of soybean cyst nematode, *Heterodera glycines*. *Plant Disease* 104. <https://doi.org/10.1094/PDIS-08-20-1778-RE>
13. Teuber, O., D. Samarappuli, and M.T. Berti. 2020. Nitrogen and sulfur fertilization in kale and swede for grazing. *Agronomy* 10(5), 619; doi:10.3390/agronomy10050619
14. Delavarpour, N., S. Eshkabilov, T. Bon, J. Nowatzki, and S. Bajwa. 2020. The Tractor-Cart System Controller with Fuzzy Logic Rules. *Appl. Sci.* 2020, 10, 5223; doi:10.3390/app10155223

### Abstracts and Presentations at conferences, workshops, symposiums

1. Berti, M.T. 2021. Does nitrogen in cover crops biomass cycles back to the next crop? 13<sup>th</sup> Nutrient Management Conference. Minnesota Agricultural Water Resource Center (virtual) 16 February 2021. *Invited speaker* (242 participants).
2. Bibby, S., M.T. Berti, A.F. Wick, D.P. Horvath, J.V. Anderson, A. Wittenberg, A. Greenberg, and K. Mozea. 2021. Corn-alfalfa intercropping with different row spacings. American Forage and Grassland Council Conference, Savannah, GA (virtual) 11-12 January 2021
3. Berti, M.T. 2020 Integrating cover crops into cropping systems for better soil health- What works what doesn't? Soil Management Summit University of Minnesota. Virtual Conference. 15-16 December 2020. *Invited*

4. Sigdel, S. A. Chatterjee, M. T. Berti, N. Cattanach. 2020. Effect of seeding time and interseeded cover crop on sugarbeet (*Beta vulgaris* L.) yield and quality. ASA-CSSA-SSSA International Annual Meetings, Phoenix, AZ, 9-14 November 2020 (virtual).
5. Mohamed, Y., R.W. Gesch, M.S. Wells, S. Patel, A.W. Lenssen, B.L. Johnson, H. Matthees, F. Forcella, and M.T. Berti. 2020. Impact of Interseeded Winter Cover Crops on Soil Nitrate in Maize-Soybean Cropping Systems ASA-CSSA-SSSA International Annual Meetings, Phoenix, AZ, 9-14 November 2020 (virtual).
6. Berti, M.T. 2020. Diversification of production systems for sustainable production of food and renewable energy while enhancing soil health. II Congreso de Desarrollo Territorial 2020: Promoviendo la Sustentabilidad. Ahuacatlán, Puebla, Mexico, 21-23 October. (Virtual presentation) *Invited plenary speaker.*
7. Berti, M.T. 2020. Biomass sorghum: the most promising energy crop in the northern Great Plains. Association for the Advancement of Industrial Crops(AAIC) Webinar Series 8-9 September, 2020. Virtual conference. *Invited speaker*
8. Neubauer, M., M.T Berti, J.V. Anderson, W. Chao, and D. Horvath. 2020. Vernalization and cold acclimation of two divergent *Camelina sativa* biotypes: An RNAseq time course study. Plant Biology Worldwide Summit, Washington, DC, 27-31 July, (Virtual)
9. Cecchin, A., M.T. Berti, and G. Pourhashem, 2020. Evaluating environmental impacts of introducing winter camelina and field pennycress into the current cropping systems in the upper Midwest of the USA. In 28<sup>th</sup> European Biomass Conference and Exhibition, Marseille, France. 6-9 July 2020 (Virtual).
10. Cecchin, A., M.T. Berti, and G. Pourhashem. 2020. Assessing environmental benefits of winter cover crops in corn-soybean rotations in the U.S. Upper Midwest. 26<sup>th</sup> International Sustainable Development Research Society. Budapest, Hungary, 15-17 July 2020. (Virtual)

#### **New Grant Funding obtained:**

1. ND Corn Utilization Council 07/2021-06/2022. Comparing and prioritizing conservation practices to enhance soil fertility and productivity in corn cropping systems. \$30,578. PI.
2. USDA-NACA 09/2020-08/2022. Agronomic and molecular responses of maize and sunflower to competition with cover crops and alfalfa. \$ 60,000, PI.
3. NC-SARE, 10/1/2020-9/30/2022, Training for effective delivery of science-based soil health information – It’s about more than just content, It’s about messaging skills. \$89,817, Co-PI
4. Midwest Forage Association, 5/2020-4/2021. Testing new high quality perennial cool-season forage grasses with improved winter hardiness and persistence, \$2000, PI
5. ND Soybean Council 7/2021-6/2022 Identifying effective cover crops for management of soybean cyst nematode. \$30,280, PI: Guiping Yan

#### **Theses and Dissertations:**

1. Sergio Cabello, Ph.D. Nutrient credits from cover crops in no-till systems in the northern Great Plains. North Dakota State University. (Berti and Franzen) August 2016- January 2021.
2. Nadia Delarvarpour, PhD., North Dakota State University, Improving the twin-row interseeder guidance system. (Bajwa and Nowatzki) January 2017-May2021.
3. Kyle Aasand, MS, Corn and soybean relay cropping with winter rye, field pennycress, and winter Camelina. North Dakota State University (Johnson) June 2016- May 2021.
4. Kory Johnson, MS. Interseeding camelina into narrow row spacing soybean of different maturity groups. North Dakota State University (Kandel) January 2017-May 2020.
5. Kenneth Mozea, MS. Biomass and botanical composition of annual forage mixtures for grazing. North Dakota State University (Berti), May 2019- December 2021.
6. Sailesh Sigdel, MS Cover crop inter-seeding under sugarbeet production. North Dakota State University (Chatterjee) May 2018-December 2020



7. Krishna Acharya, PhD. Managing soybean cyst nematode with cover crops. North Dakota State University (Yan). August 2017- May 2020.
8. Marcus Mack, MS Rye termination timing study in relation to soybean planting date. North Dakota State University (Ransom) May 2018-May 2021.
9. McKayla Neubauer, MS, Molecular changes in the transcriptome of camelina and alfalfa under competition (Horvath, Anderson, Berti) 2020-2022
10. Brady Goettl, MS, N fertilizer recommendations for North Dakota two-row malting barley (Wick & Franzen) 2020-2022

### **Graduate students and Postdoctoral Researchers in Cover Crops Research**

*Number of MS students: 7*

*Number of Ph.D. students: 3*

*Number of Postdoctoral Researchers: 1*

Dr. Andrea Cecchin, Environmental impact of cropping systems using cover crops. (Berti)

### **Extension publications/bulletins:**

1. Berti, M.T. 2021. Perennial cool-season grasses for hay in the Midwest. Forage Focus March 2021 p. 8. Midwest Forage Association, St. Paul, MN
2. Meehan, M., M. Keena, M.T. Berti, K. Sedivec, M. Ostlie, and E. Gaugler. 2020. Integration of Crop & Livestock Systems in North Dakota. 2020.Beef & sheep report.
3. Berti, M.T. and O. Teuber, 2020. Fertilization of full-season forage brassicas for grazing. Forage Focus May 2020, p.7.
4. Sedivec, K., M. Meehan, E. Gaugler, M. Berti, F. Brummer, P. Nester 2020. Annual cover crop options for grazing in the northern Plains. Bull. R1759. North Dakota State University Extension Service.
5. Yan, G. P., Berti, M., and Markell, S. 2019. Screening cover crops for managing soybean cyst nematode and other nematodes in infested soils. Research: The Key to Success, 2019 Research Report. Pp. 34, North Dakota Soybean Council.
6. Berti, M. and Yan, G. P. 2019. Host and non-host cover crops of soybean cyst nematode. NDSU Extension Fact-Sheet.
7. Franzen, D., D. Wick, J. Ransom, N. Kalwar, and H. Kandel. Considerations of Cover Crop Choices for Prevent Plant Acres. Crop Pest Report, June 4, No 6: 11-12.  
<https://www.ag.ndsu.edu/cpr/soils/considerations-of-cover-crop-choices-for-prevent-plant-acres-6-04-20>
8. Kandel, H. Cover Crop Planted Into Sunflower. Crop Pest Report. June 18, No 8: 5-6.  
<https://www.ag.ndsu.edu/cpr/plant-science/cover-crops-planted-into-sunflower-06-18-20>

### **Extension Videos Produced**

**Total Videos Produced: 49; Plays: over 200,000; Subscribers: 1,260 (12/28/20)**

Briese, L., A.F. Wick. 2021. #TailgateTalk Soil Health. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=nYR1ynpdDh0>

Briese, L., A.F. Wick. 2021. Do YoYo's Help with Soil Health. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=c95T90XFYuk>

Breker, J., A.F. Wick. 2021. #TailgateTalk Soil Health. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=8WFjyn3-orw>

Hammerich, T., A.F. Wick. 2021. Pursuit of Healthier Soils, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=uh4ajdTjL4o>

Schuster, S., S. Landman, L. Trautman, A.F. Wick, T. Hammerich. 2021. Research Discussion: Reducing Tillage, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=5BRGBrLXGlw>

Bly, A., A. Daigh, C. Gasch, A.F. Wick, T. Hammerich. 2021. Research Discussion: Reducing Tillage, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=S\\_itVtaAlYI](https://www.youtube.com/watch?v=S_itVtaAlYI)

Wagner, T., D. Forgey, G. Amundson, A.F. Wick, T. Hammerich. 2021. On-Farm Discussion: Cover Crops, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=-aFuRgZJstc>

Franzen, D., M. Ruark, H. Kandel, S. Gailans, A.F. Wick, T. Hammerich. 2021. Regional Research Discussion: Cover Crops, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=Gx8ubRIW4U8>

Chatterjee, A., G. Endres, A.F. Wick, T. Hammerich. 2021. Research Discussion: Cover Crops in Specialty Crops, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=\\_mG97oz1ZSo](https://www.youtube.com/watch?v=_mG97oz1ZSo)

Ostlie, M., J. Ransom, L. Briese, K. Cooper, A.F. Wick, T. Hammerich. 2021. Research Discussion: Wide Row Corn, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=9PVBKWvsJ-Y>

Breker, J., C. Walberg, T. Zimmerman, M. Schaefer, A.F. Wick, T. Hammerich. 2021. On Farm Tips and Ideas: Wide Row Corn, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=wpo9\\_k3jDlk](https://www.youtube.com/watch?v=wpo9_k3jDlk)

Berti, M., R. Gesch, M. Ostlie, A.F. Wick, T. Hammerich. 2021. Research Discussion: Intercropping and Relay Cropping, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=2ltyr2cHeCs>

Kalwar, N., C. Reese, A.F. Wick, T. Hammerich. 2021. Research Discussion: Managing Salts, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=CZhubUSAvyo>

Beutow, R., M. Liebig, A.F. Wick, T. Hammerich. 2021. Research Discussion: Managing Low pH Soils, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=4j3i8F5QbOs>

Wick, A.F. 2021. DIRT Evaluation and Network, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=aeJZZkyvPHk>

Landman, S., A.F. Wick. 2021. #OnFarm at the SHARE Farm. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=YGLhx5anTu4>

Breker, J., T. Zimmerman, M. Ostlie, R. Gesch, A.F. Wick. 2021. Wide Row Corn, Intercropping and Relay Cropping. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=aesu9gqAqsE>

Breker, J., A.F. Wick. 2020. Wide Row Corn: Twin Row Spacing and Harvestability, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=pE8ZD3fGr2Y&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=31>

Buetow, R., A.F. Wick. 2020. Managing Low pH Soils, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=nZbiRieu1jg&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=30>

Kalwar, N., A.F. Wick. 2020. Soil Salinity Impacts and Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=G6erX\\_Zj7FM&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=29](https://www.youtube.com/watch?v=G6erX_Zj7FM&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=29)

Gesch, R., A.F. Wick. 2020. Relay Cropping: Winter Camelina and Soybean, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=ToARKeXOn-4&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=28>

Berti, M., A.F. Wick. 2020. Intercropping: Alfalfa and Corn, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=-4twZQopP2I&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=27>

Reese, C., A.F. Wick. 2020. Sodic Soil Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=Nn5z85\\_Oe8o&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=26](https://www.youtube.com/watch?v=Nn5z85_Oe8o&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=26)

Liebig, M., A.F. Wick. 2020. Soil Acidification in Annual Cropping Systems, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=T\\_ox32WkuOk&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=25](https://www.youtube.com/watch?v=T_ox32WkuOk&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=25)

Meehan, M., A.F. Wick. 2020. Livestock and Cover Crops: Grazing Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=O\\_HQPiwJJ4M&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=24](https://www.youtube.com/watch?v=O_HQPiwJJ4M&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=24)

Keena, M., A.F. Wick. 2020. Compost and Manure: Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=A1KZcu\\_K5Hw&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=23](https://www.youtube.com/watch?v=A1KZcu_K5Hw&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=23)

Sedivec, K., A.F. Wick. 2020. Livestock and Cover Crops winter Cereals for Grazing, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=raS-DvmeRBg&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=22>

Schaefer, M., A.F. Wick. 2020. Wide-Row Corn Ideas: Growing Vegetables, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=Ulw3VzEEExOg&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=21>



Ransom, J., A.F. Wick. 2020. Comparing 30” and 60” Corn: Plant Population and Cover Crop Selection, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=1S6tdEmNPtA&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=20>

Briese, L., A.F. Wick. 2020. Comparing 30” and 60” Corn in On-Farm Research, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=1kk7N8PhcSI&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=19>

Zimmerman, T., A.F. Wick. 2020. Wide-Row Corn: Navigating the System On-Farm, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=DUg5TAseWmY&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=18>

Wick, A.F., C. Walberg. 2020. Wide Row Corn Silage and Grazing, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=uVelWFkuOSI&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=17>

Ruark, M., A.F. Wick. 2020. Using Cover Crops in Wisconsin, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=ORXz4eVBGok&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=16>

A.F. Wick. 2020. Wide Row Corn: Connecting Research and On-Farm Trials, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=uTovbV-FZe8&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=15>

Ostlie, M., A.F. Wick. 2020. Wide-Row Corn Agronomic Considerations and Goals, DIRT Workshop 2020, Extension Education Video, InHouse Productions, [https://www.youtube.com/watch?v=Fr\\_pxwBHelA&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=14](https://www.youtube.com/watch?v=Fr_pxwBHelA&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=14)

Kandel, H., A.F. Wick. 2020. Cover Crop Options after Wheat, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=aaWyK06Vh5I&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=13>

Endres, G., A.F. Wick. 2020. Planting Green into Cereal Rye with Dry Beans, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=IpR9hh5jfKk&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=12>

Franzen, D., A.F. Wick. 2020. Managing Fertility with Cover Crops in Rotation, DIRT Workshop 2020, Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=MJUaEVShR6U&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=11>

Daigh, A., A.F. Wick. 2020. Reduced Tillage: Soil Moisture and Temperature, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=aE0e4s7VIkY&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=10>

Wick, A.F., 2020. Soil Health and Cover Crops: SHARE Farm Logan Center, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=CoSQ1UZ33w4&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=9>

Ransom, J., A.F. Wick. 2020. Planting Soybean into a Living Cover Crop, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=E772UIRV8ls&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=8>

Kandel, H., A.F. Wick. 2020. Broadcasting Cover Crops into Soybean, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=0Iy8HTrxLII&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=7>

Meehan, M., A.F. Wick. 2020. Grazing Cover Crops Benefits and Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=M16cP9MwC4U&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=6>

Wick, A.F., C. Walberg. 2020. Full-Season Cover Crops at Chris Walberg's Ranch, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=bOZxmvC2d80&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=5>

Wick, A.F., M. Berti. 2020. Cover Crops Below the Surface, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=mvrH1jks3mU&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=4>

Berti, M., A.F. Wick. 2020. Brassica Cover Crop Selection and Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=Dti3CkiI88s&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=3>

Berti, M., A.F. Wick. 2020. Grass Cover Crop Selection and Management, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
[https://www.youtube.com/watch?v=R\\_o6hmVf6H0&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=2](https://www.youtube.com/watch?v=R_o6hmVf6H0&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa&index=2)

Wick, A.F. 2020. Long-Term No-Till and Cover Crops, DIRT Workshop 2020, Extension Education Video, InHouse Productions,  
<https://www.youtube.com/watch?v=FlbMAMkMTLA&list=PLkmGaTzxww1Gr7WTNoG7mcusYnftOKtxa>

Wick, A.F. 2020. DIRT 2020 Promotional Video. Extension Education Video, InHouse Productions, <https://www.youtube.com/watch?v=CpyP3AXr9qk>

### **Field days**

1. Cover crops options. Zoom webinar (CAP TEAM), August 11, 8:15-8:30 a.m. [35 participants].
2. Interseeding soybean with cover crops Sargent County plot tour, Gwinner. Included planted demonstration with rye and camelina seeded into soybean. Sept., 5-5:30 p.m. [15 participants].
3. Interseeding soybean with cover crops Ransom County plot tour. Included planted demonstration with rye and camelina seeded into soybean Lisbon, Sept. 9, 5:30- 6 p.m. [14 participants].
4. Regional Research Discussion Cover Crops, Panel Discussion. Dakota Innovation Research and Technology (DIRT) workshop, December 8, 2-2:40 p.m. [274].
5. Utilizing Sunlight after the Main Crop: Cover Crops after Wheat and Interseeded into Soybean. Prairie Grains Conference, Virtual conference. December 10, 12:30-1:05 p.m. [32].  
<https://www.youtube.com/watch?v=vfk9WRb8t3I&feature=youtu.be>

### **Workshops and professional training**

Total Workshops and Tours: 14, Total Attendees: 1,690 (Live), 1,137 (Views Recording)

#### **1. Grazing cover crops Webinar series 2020**

Tuesday, April 7<sup>th</sup>-Cover Crop Seed Regulations, Marisol Berti; Herbicide Residual Considerations, Mike Ostlie

Thursday, April 9<sup>th</sup>-Cover Crop Grazing Research, Kevin Sedivec; Economic and Soil Impacts of Cover Crops, Erin Gaugler

Tuesday, April 14<sup>th</sup>- Forage Grazing Calculator, Miranda Meehan; Cover Crop Toxicity Issues, Janna Block

Thursday, April 16<sup>th</sup>-Cover Crop Characteristics and Identification, Mary Keena and Marisol Berti

Tuesday, April 21<sup>st</sup>-Winter Grazing & Alfalfa Production, Megan Van Emon; Sainfoin Quality, Yield & Condensed Tannin Content, Kylie Gardhouse

#### **2. Communication Workshop-Engage in better information exchange (7 December 2020) Virtual**

#### **3. Dakota Innovation Research and Technology (DIRT) Workshop, December 8-9, 2020, Virtual Live-Hosted (Wick, 450 attendees)**

#### **4. Other workshops/webinars:**

Soil Talk Tuesdays: Making Soil Health Practices Fit, February 23, 2021, Virtual, Live-Hosted (Wick, 100 attendees)

Soil Talk Tuesdays: Wide Row Corn, Intercropping and Relay Cropping, February 9, 2021, Virtual, Live-Hosted (Wick, 100 attendees)

Soil Talk Tuesdays: Managing Problematic Soils (Salts, Low pH), February 2, 2021, Virtual, Live-Hosted (Wick, 100 attendees)

Soil Talk Tuesdays: Weed, Disease and Pest Management in Soil Health Systems, January 26, 2021, Virtual, Live-Hosted (Wick, 100 attendees)

Soil Talk Tuesdays: Getting the Most out of Grazing Cover Crops, January 19, 2021, Virtual, Live-Hosted (Wick, 100 attendees)

Soil Talk Tuesdays: Using Cover Crops Effectively, January 12, 2021, Virtual, Live-Hosted (Wick, 105 attendees)

Soil Talk Tuesdays: Management in Reduced Till Systems, January 5, 2021, Virtual, Live-Hosted (Wick, 170 attendees)

Soil Health Webinar Series – Salinity. Virtual, May 14, 2020 (75 attendees live; 140 views of recording – 1/22/21; Kalwar, Wick)

Soil Health Webinar Series – Grazing. Virtual, May 12, 2020 (75 attendees live; 131 views of recording – 1/22/21; Kalwar, Wick)

Soil Health Webinar Series – Cover Crops. Virtual, May 7, 2020 (75 attendees live; 184 views of recording – 1/22/21; Kalwar, Wick)

Soil Health Webinar Series - Fertility. Virtual, May 5, 2020 (75 attendees live; 131 views of recording – 1/22/21; Kalwar, Wick)

Soil Health Webinar Series – Soil Health and Wet Conditions. Virtual, April 30, 2020 (75 attendees live; 364 views of recording – 1/22/21; Kalwar, Wick)

Soil Health Webinar Series – Managing Ruts and Compaction. Virtual, April 28, 2020 (90 attendees live; 187 views of recording – 1/22/21; Kalwar, Wick)

### Café Talks

Café Talk, Cover Crops after Wheat of Barley. Dakota Innovation Research and Technology (DIRT) workshop, December 8, 11-12:30 p.m. (three 30 min segments [16, 18, 19 participants]).

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### **PODCASTS AND WEBINARS**

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**Soil Sense Podcast Episodes: 25**

**Field Check Podcast Episodes:** 12 (episodes posted online and also played on radio with Mick Kjar, Farm Talk on AgNews 890 to reach 10,000 people each episode)

**Webinars: 6**

\*Each podcast episode has been played over 1,000 times.

**Wick, A.F.** 2021. Soil Sense Podcast, Season 4, 15 Episodes to be released weekly with different guests, Host: Tim Hammerich (**77,802 plays as of February 20, 2021**)

Farmer Experience with Wide Row Corn with Tyler Zimmerman (farmer, Leonard, ND), Chris Walberg (farmer/rancher, Leonard, ND) and Joe Breker (farmer, Rutland, ND), Feb 15

Cover Crops Research and Strategy with Hans Kandel (NDSU), Matt Ruark (UWisc), Dave Franzen (NDSU), February 8

What Happens in the Soil when we Reduce Tillage? With Anthony Bly (SDSU), Aaron Daigh (NDSU), Caley Gasch (NDSU), February 1

**Wick, A.F.** 2020. Soil Sense Podcast, Season 3, 15 Episodes to be released weekly with different guests, Host: Tim Hammerich (**72,262 plays as of January 22, 2021**)

DIRT Workshop Roundup: Strip Tillage, Cover Crops, Relay Crops, and Grazing, December 28

Interstate Collaboration with Bill Spiegel (farmer, Manhattan, KS, Editor Successful Farming) and Dr. Abbey Wick (NDSU), December 21

Transitioning the Farm to the Next Generation with Kari Olson (NDSU, farmer, Hawley, MN), December 14

Bale Grazing with Erin (NDSU) and Drew Gaugler (rancher, western ND), December 1

The Importance of Extension with Dr. Greg Lardy (NDSU), November 23

Managing Low pH Soils with Ryan Buetow (NDSU) and Nathan Thomas (farmer, Western ND), November 16

Cultivating the Right Mindset with Monica McConkey (LPC, Detroit Lakes, MN) November 9

Strategies for Keeping Living Roots in the Soil with Paul Thomas (farmer, Velva, ND), November 2

Grazing Management with Dr. Miranda Meehan (NDSU), October 26

Educating the Next Generation with an Ag Teacher, Whitney Landman (Ag Education, Larimore High School), October 19

Rock and Roll Agronomy, Jason Hanson (independent crop consultant), October 12

Cover Crops: Science, Practice, and Mindset, Greg Endres (NDSU), Greg Amundson (farmer, Gilby, ND), October 5

Interseeding Cover Crops, Marisol Berti (NDSU), Yvonne Lawley (University of Manitoba), September 28  
 Stories of Soil Health, Gil Gullickson (Editor Successful Farming Magazine), September 21  
 Systems Thinking, Woody Van Arkel (farmer, Ontario), Lee Briese (Centrol Crop Consulting), September 14

**Wick, A.F.** 2020. Soil Sense: Field Check Podcast, Season 1, 12 Episodes released weekly with different guests, Host: Tim Hammerich (**43,549 plays as of 9/13/20**)  
 Decades of Soil Health Building Practices, Kerry Swindler (farmer, Mott, ND), Abbey Wick (NDSU), August 31  
 Understanding Soil Biology, Sam Banerjee (NDSU), Paul Temple (farmer, UK), August 24  
 Infiltration During Intense Rain Events, Aaron Daigh (NDSU), Bill Spiegel (farmer, KS), August 17  
 Managing the Complexities of Adding a New Crop, David Ripplinger (NDSU), Jocelyn Velustik (Independent Crop Consultant, SK), August 10  
 Getting Started with Cover Crops, Abbey Wick (NDSU), Jason Hanson (Rock and Roll Agronomy), August 3  
 Hybrid Rye, Steve Zwinger (NDSU), Luke Struckman (Ottawa, ON, Canada), July 27  
 Fertility for No-Till Corn, Dave Franzen (NDSU), Kyle Geske (farmer, Enderlin, ND), July 20  
 Tradeoffs of Planting Green, Lee Briese (Centrol Crop Consulting), Nathan Neameyer (farmer, Rolla, ND), July 13  
 How to Revive Nutrient Depleted Forage Ground, Kevin Sedivec (NDSU), Clay Conry (cow/calf operator South Dakota), July 6  
 Cutworms in Soybeans Planted Green into Cover Crop, Jan Knodel (NDSU), Chris Prochnow (Agassiz Seed and Supply), June 22  
 Considering Crop Rotation when Selecting Cover Crops, Andrew Friskop (NDSU), Brian Kenner (farmer, Maddock, ND), June 22  
 Cereal Rye for Kochia Control and Dicamba Update, Joe Ikley (NDSU), Jason Hanson (Rock and Roll Agronomy), June 15

Kalwar, N. and **A.F. Wick.** 2020. Soil Health Webinar Series, Kalwar and Wick hosting. April 28 – May 14, Webinar.  
 Challenges with Residue, Tillage and Ruts Following Wet Harvest, April 28, Aaron Daigh (75 attendees; 134 plays 10/19/20)  
 Cover Crops for Wet Field Conditions, April 30, Abbey Wick (52 attendees; 175 views 10/19/20)  
 A History of Phosphorous Export from North Dakota, May 5, Dave Franzen (62 plays 10/19/20)  
 How to Select a Cover Crop According to My Cropping Plan, May 7, Marisol Berti (112 views 10/19/20)  
 Rejuvenating Pastures and Adding Value to Perennial Grass Mixtures, May 12, Kevin Sedivec  
 Soil Salinity and Sodicity Challenges, May 14, Naeem Kalwar

**Wick, A.F.** 2020. Soil Sense Podcast, Season 2, 7 Episodes released since April 1, 2020 weekly with different guests, Host: Tim Hammerich (**29,158 plays as of 6/14/20**).  
 Collaborations to Advance Soil Health, Tim Hammerich (Host), June 8  
 Measuring Soil Quality, Soil Health Dynamic Duo, Part 2, Susan Samson-Liebig (NRCS), Mark Liebig (USDA ARS), June 1  
 Soil Health Dynamic Duo, Part One, Susan Samson-Liebig (NRCS), Mark Liebig (USDA ARS), May 25  
 Decades of Soil Health Collaboration, Brad Brummond (NDSU), May 18  
 Soil Health and the City, Sally Jacobson (Red River Zoo), Abbey Wick (NDSU), May 11  
 A Soil Health Journey from Crops to Cattle, Mike Schaefer (farmer), May 4  
 Intercropping and Soil Health, Mike Ostlie (NDSU), Lana Shaw (SERF), April 26  
 Strip-Till and Cover Crops, Mark Olson (farmer), Matt Olson (crop consultant), April 19

Cover Crop Seed Considerations, Steve Zwinger (NDSU) and Jason Goltz (ND State Seed Department), April 12

The Value of Livestock to Soil Health, Kevin Sedivec (NDSU), April 5

### Websites

1. CropSys CAP website [www.cropsyscap.org](http://www.cropsyscap.org): 26,065 visits pages viewed in 2020.
2. NDSU Soil Health website: <https://www.ndsu.edu/soilhealth/> Continues to be an outlet for soil health information including circulars to download, links and videos. It is also used to do on-line registrations, post conference information. An RSS feed was started in November, 2017 for the “in the news” tab to notify subscribers when a new story highlighting NDSU Soil Health is posted. 929 subscribers to YouTube Channel.  
Extension events for the CAP and extension materials are published on this site as well as in the CropSys CAP website.

### **IMPACT STATEMENT**

Research on cover crops in North Dakota includes four of the objectives in this regional committee: 1) assess the impact of cover crops on soil health, and agronomic production and profitability; 2) develop recommendations for cover crops establishment (rates, timing, application method) across production systems; and 3) evaluate cover crops for grazing

Soil erosion by wind is a serious problem in North Dakota especially in winter with little snow cover or dry springs. Cover crops are improving soil health, reducing erosion, and increasing sustainability of cropping systems. In the long-term cover crops will help reduce N fertilization and improve water quality, and provide forage for grazing.

Research on cover crops interseeding has also increased in the last few years and many farmers are interseeding cover crops in standing corn, soybean, and sunflower either by using a interseeder drill or a broadcast system (aerial or modified sprayer). Interseeding cover crops into standing corn or soybeans is an alternative for corn-soybean farmers, since there is no time to establish a cover crop after corn or soybean harvest. However, most research is showing that there is not enough light under the corn or soybean canopy to support the growth of a cover crop interseeded early in the season. Thus, research now is focusing in 60” corn and sunflowers for an adequate establishment of cover crops to improve soil health and as forage for grazing.

Total area of cover crops is unknown but we believe it easily surpassed 500,000 acres in North Dakota. Cover crops adoption in North Dakota is increasing dramatically thanks to the many researchers (14) and graduate students (10) involved in cover crops research and extension in the state. Researchers were able to secure \$215,610 in new funding for cover crops research in 2020, Researchers working in cover crops and soil health published 14 peer-reviewed articles, 8 extension publications, 11 presentation in conferences, workshops and symposiums, five field days, and 49 videos. Many webinars were organized during the season in replacement of in-person activities.

A survey to growers in ND, IA, and MN participating in at least one extension event from 2016-2020, were conducted. Ninety-three percent (93%) of grower respondents represented 257,600 acres of farmland across the three participating states. As expected, more acres are leased than owned. Eighty-two percent (82%) of consultant respondents cover 760,000 acres across the three states. Median acres covered by consultant respondents was 30,000 acres. Six cover crop-related practices represented the greatest impact on grower respondents since 2016. The greatest of these was evaluating soil health on your fields (35% started after 2016), followed closely by using cover crops to manage weeds, insects, and diseases (34% started after 2016).



## Grazing Management Practices to Enhance Soil Health in the Northern Great Plains

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### Summary

*The objective of this project is to identify the impacts of livestock grazing management on the environmental and economic sustainability of an integrated crop and livestock system. Our focus is on the influence of stock density and forage utilization on 1) soil physical and chemical properties, 2) crop production, 3) livestock production and 4) economics.*

### Introduction

Cover crops have gained popularity as a practice implemented by producers across the United States. According to the USDA Census of Agriculture 15.4 million acres were planted to cover crops in 2017, up 50% from the 10.3 million acres in 2012 (USDA, 2019; USDA, 2014). North Dakota is no exception to this trend with producers incorporating cover crops to improve soil health and increase crop production (USDA, 2019; CTIC, 2017). Despite the ecological benefits of incorporating cover crops into a system, the economic benefits may not be realized if livestock are not incorporated into the system (Costa et al., 2014; Franzluebber and Stuedemann, 2015).

The benefits of integrated crop and livestock systems (ICLSs) include enhanced nutrient cycling as well as reduced inputs and livestock feeding costs. The majority of research evaluating ICLSs has been conducted in regions characterized by humid climates. Research on the ecological impacts of ICLSs in semi-arid ecosystems, such as the Northern Great Plains is limited (Faust et al., 2018).

Livestock management decisions, such as stocking rates, stock density and utilization have the potential to impact the environmental and economic sustainability of ICLSs. Limited information is available to producers in the Northern Great Plains to help make these management decisions. This producer-led demonstration project will aid in the development of best management practices for managing grazing livestock in ICLSs to enhance soil health, livestock production, crop production and economic sustainability.

### Procedures

A three-year ICLS project was initiated during the spring of 2020. NDSU Extension partnered with producers to establish six demonstration sites located in central North Dakota, along with a host site on the main campus of NDSU. An annual forage crop was subjected to two grazing density treatments: 1) moderate and 2) high. Additionally, two forage utilization rates were evaluated: 1) 50% and 2) 75%. A non-grazed treatment served as the control. Treatments will be imposed for two years, followed by a cash crop.

Each location was developed to test grazing density treatments in a split-plot design. Three producers demonstrated the high stock density at two utilization rates (50% and 75%), while three producers demonstrated the moderate stock density at the same two utilization rates. The Fargo location provided a study of all treatments and utilization rates.

### Forage Establishment

The annual forage crop planted by mid-June of 2020 and 2021 included and will include oats, sorghum sudangrass, foxtail millet, sunflower, radish, kale, turnip, flax and forage pea seed seeded at a rate of 18, 3, 2, 1.5, 1, 0.75, 0.75, 2 and 10 lbs/ac, respectively. Following two years of an annual forage crop, the planned cash crop will be corn planted in the spring of 2022.

### Livestock and Grazing Management

Cattle were randomly assigned to grazing density treatments and carrying capacities were determined based on available forage production and estimated utilization. Stocking rates were determined by dividing the available forage by anticipated dry matter intake per day, then dividing by 30 days of planned grazing to predict the number of cows per plot. The available forage for 50% and 75% utilization treatments was calculated at 35% and 50% of the total forage produced, respectively (Meehan et al., 2018). The estimated dry matter intake was based on recommendations in the Beef Cattle Handbook (National Research Council, 2016). The moderate stock density was based on the recommended stocking rate for a 30 day period. The high stock density was set at double the moderate stock density and the grazing period reduced so as to ensure the treatment was not overgrazed. During 2020, turnout dates ranged from late August to early October.

Electric poly-wire and temporary posts were utilized as portable cross-fence to limit-graze livestock and maintain grazing efficiency. Each treatment was divided into four sections. Windbreak shelters were available for use and continued access to water was provided.

### Soil Sampling

Soil samples were collected to characterize physical, chemical and biological properties. Soil physical properties included bulk density, infiltration and soil aggregate stability collected pre- and post-treatment. Six sub-samples were collected from a similar soil series within each treatment prior to seeding of annual forage crop. Samples were also collected from a nearby location that was managed as part of a traditional cash crop system. Soil chemical properties included soil nutrients, pH and organic matter collected annually with assessment of nutrient distribution occurring pre- and post-treatment only. Sub-samples for nutrient distribution were collected from each 1 acre sub-plot, whereas once yearly levels were extracted from a similar soil series within each treatment. Above ground residue was gently removed at each sampling site prior to conducting the sampling technique.

A soil core sampler with hammer attachment was used to measure bulk density at a depth of 0-6 inches. In calculating bulk density, the weight of the oven-dried soil was divided by the volume of the ring to determine lb/ft<sup>3</sup>.

Soil infiltration was determined by utilizing the Cornell Sprinkle Infiltrometer system (van Es and Shindelbeck, 2003). It consists of a portable rainfall simulator that is placed onto a single 9.5



inch inner diameter infiltration ring and allows for application of a simulated rainfall event. Field-saturated infiltrability reflects the steady-state infiltration capacity of the soil, after wet-up. It is based on the data collected at the end of the measurement period, or whenever steady-state conditions occur. Since the apparatus has a single ring, conversion factors from Reynolds and Elrick (1990) are needed to account for the three-dimensional flow at the bottom of the ring.

Soil aggregate stability samples were collected with a tiling spade to a depth of 0-6 inches. A manual wet sieving method by Six et al. (1998) was used to develop an automated method for assessing aggregate stability. Due to variation in soil across locations, the sand correction procedure by Mikha and Rice (2004) was applied to each sample to remove the sand fraction from the water stable aggregates total.

Soil nitrate nitrogen ( $\text{NO}_3\text{-N}$ ), carbon (C), phosphorus (P), potassium, pH, organic matter (OM), sulfate-sulfur ( $\text{SO}_4\text{-S}$ ), zinc and copper (Cu) were determined from samples collected at 0-6 and 6-12 inches with a 0.7 inch diameter soil probe. Soil nitrates (Vendrell and Zupancic, 2008) were measured using the Brinkmann PC910 Colorimeter. This colorimeter was also used to determine levels of P after applying the Olsen Test (Nathan and Gelderman, 2015). Potassium was measured using an atomic absorption spectrophotometer. Zinc and copper were extracted with diethylene triamine penta acetic acid and also measured with an atomic absorption spectrophotometer (Nathan and Gelderman, 2015). Recommended chemical soil test procedures for the North Central Region (Nathan and Gelderman, 2015) were used to analyze C, pH, OM and  $\text{SO}_4\text{-S}$ .

#### Forage Production and Utilization

Forage production and utilization of the annual crop was estimated by clipping six 59-inch diameter hoops per experimental treatment. Clipping for peak biomass production occurred during the week prior to grazing and turnout dates ranged from late August to early October. Clipping to determine forage utilization occurred upon removal of cattle from the grazing treatments.

#### Livestock Performance

Beef cattle were stratified by a 2-day body weight and body condition score at the site in Fargo pre- and post-treatment, whereas cattle at the demonstration sites were scored for their body condition only. A visual scoring system developed by Wagner et al. (1988) was used to assess body condition.

### **Results and Discussion**

#### Year One

Growing season conditions (Table 1) and field preparation appeared to impact germination of annual forage species and production (Table 2). Stocking rates were adjusted for locations with a significant amount of weed competition as forage utilization was likely reduced. It was also noted that seeding depth impacted germination of brassica species. Any location that seeded the annual forage crop to a depth greater than  $\frac{3}{4}$  inch experienced little to no germination of brassicas.

Location	Rainfall (inches)	Month						Seasonal Total
		May	June	July	August	September	October	
Fargo <sup>1</sup>	Total	1.5	2.6	5.3	4.8	0.9	0.9	16.0
	Normal Total	2.8	3.9	2.8	2.6	2.6	2.2	16.9
Jamestown <sup>1</sup>	Total	2.2	0.4	3.5	2.4	0.2	0.4	9.1
	Normal Total	2.7	3.5	3.3	2.1	2.3	1.7	15.6
McKenzie <sup>1</sup>	Total	.7	.9	3.5	0.7	0.5	0.5	6.8
	Normal Total	2.4	3.2	2.9	2.3	1.6	1.3	13.7
Napoleon <sup>2</sup>	Total	2.0	1.5	2.8	2.0	0.7	0.5	9.5
	Normal Total	2.8	3.5	3.0	2.2	1.7	1.6	14.8
Lehr <sup>1</sup>	Total	1.7	1.6	3.1	2.9	0.7	0.2	10.2
	Normal Total	2.6	3.0	2.7	2.0	1.3	1.6	13.2
McClusky <sup>2</sup>	Total	1.0	2.0	2.4	3.8	0.2	0.4	9.8
	Normal Total	2.4	3.2	2.6	2.1	1.6	1.4	13.3
Tappen <sup>1</sup>	Total	1.5	2.4	2.3	4.0	0.3	0.2	10.7
	Normal Total	2.6	3.2	3.2	2.2	2.0	1.5	14.7

<sup>1</sup> Data obtained from the North Dakota Agricultural Weather Network (2020) from or near specific locations.

<sup>2</sup> Data obtained from National Weather Service (2020).

Table 1. Average monthly precipitation levels and seasonal totals (inches) by month at each project location during the 2020 growing season.

Location	Treatment		Peak Production (lbs/ac)	Carrying Capacity (AUMs/ac)	Number of Grazing Days	Degree of Use (%)
	Stock Density	Grazing Utilization (%)				
Fargo	High	50	4892	1.40	11	38
		75	5671	2.32	18	58
	Moderate	50	6940	1.99	28	63
		75 <sup>1</sup>	6249	2.56	35	64
	Control	0	3914			
Jamestown <sup>2</sup>	High	50	7181	2.06	33	44
		75	6490	2.66	33	52
	Control	0	6548			
McKenzie	High	50	9333	2.68	36	53
		75	7714	3.16	41	68
	Control	0	8079			
Napoleon <sup>3</sup>	High	50	5593	0.72	30	52
		75	4917	0.91	37	66
	Control	0	4669			
Lehr	Moderate	50	12725	3.65	64	51
		75	11017	4.52	62	55
	Control	0	14437			
McClusky <sup>4</sup>	Moderate	50	7164	2.06	24	34
		75 <sup>5</sup>	6893	0.99	24	40
	Control	0	6375			
Tappen <sup>6</sup>	Moderate	50	10536	3.02	18	39
		75	8782	3.60	18	56
	Control	0	6444			

<sup>1</sup>Livestock pulled early due to inclement weather and limited feed.

<sup>2</sup>Livestock pulled early due to inclement weather and limited feed.

<sup>3</sup>Forage production consisted of 50-60% weeds. Stocking rate was adjusted accordingly.

<sup>4</sup>Livestock pulled early due to inclement weather.

<sup>5</sup>Forage production consisted of 65% weeds. Stocking rate was adjusted accordingly.

<sup>6</sup>Livestock pulled early due to issues with water. Degree of use is based on the first two sections within each treatment.

Table 2. Average forage production (lbs/ac), carrying capacity (AUMs/ac), number of grazing days and degree of use (%) by grazing treatment and location during 2020.

Grazing start dates ranged from late August to early October 2020. The annual forage mix was designed to not only meet nutrient requirements of beef cattle, but also to maintain or improve ecological benefits. These objectives are difficult to achieve when growing season conditions or field preparation negatively impact brassica germination. An early September frost also slowed down or halted plant growth which impacted the forage quality available to livestock. In year

two, we hope to maintain a consistent depth of seeding across locations and begin grazing the treatments by mid- to late-August.

Soil samples were collected to characterize physical, chemical and biological properties in both ICLS sites and nearby cash crop systems. Baseline data for soil nutrients is reported in Table 3. Data associated with soil physical characteristics is still being processed. Information collected in year one will serve as a baseline for evaluating response to treatments.

Location	Cropping System	Soil Ecological Type	Depth (in)	NO <sub>3</sub> -N (lbs/ac)	P (ppm)	K (ppm)	pH	OM (%)	SO <sub>4</sub> -S (lbs/ac)	Zn (ppm)	Cu (ppm)	
Tappen	ICLS	Very Droughty Loam	0-6	20	7.5	243	7.5	3.9	7.1	1.37	0.54	
			6-12	12	6.0	162	7.8	2.0	5.5	0.42	0.55	
	Annual Crop		0-6	12	14.7	348	7.9	3.1	6.8	1.68	0.45	
			6-12	8	2.7	195	8.1	2.3	5.3	0.66	0.48	
Napoleon	ICLS	Droughty Loam	0-6	20	11.8	205	6.2	3.6	10.0	0.91	0.73	
			6-12	9	4.0	137	6.6	2.8	5.4	0.40	0.69	
	Annual Crop		0-6	14	6.3	138	6.4	4.7	6.0	1.01	0.72	
			6-12	9	3.0	84	6.8	3.5	7.5	0.40	0.61	
Wishek	ICLS	Loam	0-6	17	7.2	256	7.3	4.3	93.8	0.96	0.95	
			6-12	7	2.6	173	7.6	2.9	86.2	0.57	0.96	
	Annual Crop		0-6	6	4.0	220	7.7	2.6	3.0	0.76	0.80	
			6-12	10	1.7	143	7.8	2.0	17.2	0.37	0.69	
Jamestown	ICLS	Loam	0-6	5	16.9	248	6.6	3.5	59.3	1.26	0.78	
			6-12	5	4.9	139	7.1	2.2	86.1	0.53	0.70	
	Annual Crop		0-6	12	23.5	290	6.4	4.0	7.8	1.53	0.59	
			6-12	13	7.7	177	6.7	2.5	6.5	0.68	0.58	
McKenzie	ICLS	Loam	0-6	14	4.2	215	5.8	2.6	6.1	0.56	0.51	
			6-12	8	2.2	110	5.9	1.7	6.9	0.25	0.52	
	Annual Crop		Very Droughty Loam	0-6	15	2.8	124	6.0	2.4	4.7	0.63	0.45
				6-12	9	1.2	71	6.9	1.5	6.2	0.25	0.45
McClusky	ICLS	Loam	0-6	31	9.7	427	7.0	3.9	27.1	1.04	0.61	
			6-12	16	5.0	285	7.4	2.9	6.7	0.39	0.66	
	Annual Crop		0-6	22	11.3	328	6.8	3.9	5.5	0.56	0.83	
			6-12	12	4.3	216	7.1	3.4	4.7	0.30	0.81	
Fargo	ICLS	Clayey Subsoil	0-6	7	8.5	315	7.3	5.3	14.1	0.90	2.19	
			6-12	5	5.0	244	7.7	3.8	35.0	0.50	2.80	
	Annual Crop		0-6	53	22.4	385	7.3	5.7	11.4	1.22	2.79	
			6-12	17	11.6	278	7.4	3.9	16.6	0.63	2.90	

Table 3. Soil nutrient and biological analysis at 0-6 and 6-12 inches (in) sampled within a similar soil series at each project location.

Livestock performance data was collected and will be provided in secondary reports. The best way to share this information is still being determined since the type of cattle (e.g. cow-calf pairs, bred heifers, fall calving cows, etc.) used for grazing was and will continue to be variable.

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