MCCC-NORTH DAKOTA ANNUAL REPORT

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RESEARCH IN PROGRESS

1. **Improving cover crops management and establishment. Modification of seeding equipment, decision tool development, and estimation of N credits to optimize cover crops establishment and management.**

1) ***Modification of planters, or improved seeding strategies for establishing cover crops in standing corn and soybean at different growth stages. (G. Breker, J. Nowatzki, and PhD student N. Delanvarpour)***
   In 2017, the accuracy of a navigation system for the grain cart attached to the interseeder was evaluated.

2) ***A cover crop aerial seeding decision aid to seed cover crops in standing corn and soybean. (Ransom, Ripplinger, Postdoc Delaporte)***
   This activity has been delayed to 2018.

3) ***Microclimate characterization under various crop growth stages to optimize prediction models. (Berti, Ransom)***
   Data was collected in corn, soybean, and corn-alfalfa cropping to characterize light conditions under the crop canopies. The results indicated that available soil water during the three weeks following interseeding is critical for the cover crop establishment and survival. Photosynthetically active radiation under both the corn and soybean leaf canopies is the main driver of interseeded cover crop growth.

4) ***Estimation of N credits from cover crops and increased N use efficiency by subsequent crops. (Franzen, Wick, PhD student Sergio Cabello)***
   Experiments were established near Rutland, and near Gardner, ND, in 2016 and 2017. Corn interseeded at stages V6-V8 with winter rye, radish or winter camelina emerged and established stands that did not compete adversely with corn performance. Soybean interseeded at V6-V8 with winter rye did not affect soybean yield, but the addition of radish and winter camelina reduced soybean yield in the first growing season.

5) ***Economic analysis of decision aids and seeding equipment modifications (Ripplinger, Postdoc Aaron Delaporte)***
   The decision-tools are currently undergoing final review, as part of NDSU Extension best management practices, and will be published online at ag.ndsu.edu/farmmanagement/tools in March 2018.

2. Introducing relay-cropping and intercropping to existing cropping systems.

a) Determining optimum time to seed winter camelina and field pennycress into standing corn and soybean in conjunction with relay cropping soybean.

Seven different experiments were conducted in 2017 to address the different aspects of this objective. As we collect information on the original proposed experiment (Study 1 below), new research questions have arisen for which we have designed new experiments. These include studies on row spacing, hybrid maturity, cover crop species, and seeding date.

1) ***Interseeding of camelina and field pennycress into standing corn and soybean (Johnson, Gesch, Lenssen, Wells, Postdoc Heather Matthees, PhD student Swetabh Patel, MS students Kyle Aasand and Nick Steffl)***
   The research was conducted at Prosper, ND, Ames, IA, and Morris and Rosemount, MN. The final results from data collected over two growing seasons from seven locations indicates that a distinct latitudinal gradient exists for optimum times to interseed winter annual cover crops into standing corn and soybean. Greater establishment success was achieved with all winter annual cover crops in this study at more northerly locations. Establishing winter annual cover crops in standing corn was more difficult, and greater success was achieved by establishment into standing soybean.

2) ***Interseeding of cover crops into standing soybean (Berti, MS student Alan Peterson)***
   The experiment consisted of six cover crops interseeded at the R4 and R6 reproductive stages of soybean. Winter pea provided the most soil cover at both environments compared with any other cover crop. Fall soil residual NO_3-N was significantly higher in the check treatment compared with the plots with cover crops.

3) ***Relative maturities and row spacing effect on establishment of interseeded cover crops into soybean (Kandel, MS student Kory Johnson)***
   When cover crops were interseeded into the early maturing soybean variety at stage R6, the cover crops coverage was nearly half compared with the cover crops interseeded at R6 in the late maturing variety. Winter rye produced nearly four times the biomass as compared with that of winter camelina.

4) ***Interseeding camelina and rye in corn at different stages, row spacing and hybrid maturity (Ransom, MS student, Melissa Geizler)***
   Corn hybrid relative maturity did not have a significant effect on fall cover crop biomass, but significantly affected spring biomass accumulation. Corn row spacing and cover crop interseeding date did not significantly affect cover crop biomass.

5) ***Interseeding faba bean, forage pea , clovers and rye into standing corn (Berti, MS student Bryce Andersen)***
   No difference in soil NO_3-N or biomass was found between the cover crop treatments or the check treatment (no cover crop) in both studies, interseeded into corn or seeded after wheat.

6) ***Cover crops variety and seeding date trial (Berti)***
   Thirty one cover crops were established on two seeding dates (27 July and 23 Aug.) in Fargo, ND, in 2017. Warm-season annuals had greater biomass N accumulation in the first seeding date than in the second seeding date. Cool-season cover crops were not as sensitive to seeding date as warm-season cover crops. Mustard family crops were among the crops that accumulated the most N in their biomass in the first seeding date. Nitrogen scavenging by cover crops prevents NO3-N from leaching, by sequestration in the cover crop biomass until next spring after the cover crop is winter killed or terminated. Availability of the N in the cover crop biomass for the next crop will depend on species, C/N ratio, temperature, and soil water content.

7) ***Winter cover crops variety trials, seeding date and morphological differentiation of winter and spring types of camelina (Berti, MS student Alex Wittenberg; Research assistants Dulan Samarappuli and Hui Li.)***

   7.1 Camelina and field pennycress variety trial.

Most field pennycress plants survived the winter of 2016/2017 in Fargo, ND, but winter survival of fall established camelina was poor due to ice sheeting. The Polish winter camelina cultivars Luna and Maczuga, bolted in October and winter-killed. This indicates their vernalization requirement is much less than 'Joelle'. Seed yield was not evaluated.

7.2 Winter camelina seeding date trial

A new experiment was initiated in 2017 to determine the effect of seeding date of Joelle on stand establishment and overwintering capacity. Experimental design was an RCBD with four replicates and six seeding dates. Morphological and phenological characteristics will be evaluated in the spring of 2018.

b) Determining pollinator activity/visitation during the spring in camelina and field pennycress (Forcella, Gesch, postdoc Heather Matthees, PhD student Swetabh Patel).

Pollinator visitation data were collected throughout the flowering period for winter camelina and field pennycress at each site in the project. The estimated average percent flowering visitation during the period of flowering was 0.5% for pennycress and 0.4% for camelina. Overall, field pennycress tended to attract more flies while camelina attracted more small (native) bees.

c) Intercropping of corn and alfalfa (Berti, Lenssen, Wells, PhD student Swetabh Patel, Research assistant Dulan Samarappuli)

The experiment was established at four and three locations in 2016 and 2017, respectively. In the seeding year, alfalfa seasonal forage yield was significantly greater when alfalfa did not have to compete with corn during establishment. Prohexadione (a growth regulator) did not improve alfalfa biomass or plant density in the seeding year. Seasonal forage yield of alfalfa established in 2016 was significantly greater than the 2017 spring-seeded alfalfa.

d) Economic analysis of cropping systems energy balance and LCA of novel cropping systems. (Ripplinger, Berti, Postdoc Aaron Delaporte)

The full economic analysis of cropping systems will consider environmental impacts that are not-priced by the market. These will include greenhouse gas emissions, acid rain, ecotoxicity, and eutrophication. These impacts will be measured economically by mapping economic costs per unit of impact using data from the literature. Sensitivity analysis will be used to identify thresholds and relative impact of the alternatives. SimaPro software will be used to conduct the Life Cycle Assessment, data from completed project field trials will be used whenever possible.

3. On-farm, outreach, and Extension activities

a) On farm replicated trials (Wick, Franzen, Kandel, Ransom; farmers Breker, Bell, Toussaint, Rollofson)

On-farm trials were conducted with the new interseeder in Rutland and Gardner, ND, in 2017. All nutrient cycling studies in both corn and soybean were done in the on-farm replicated trials (results in Obj. 1d). In Morris, MN, 5 acres were planted with winter camelina in the fall of 2016. In May 2017, soybean was relayed planted into standing camelina and camelina grain was harvested at the end of June. Strips of cover crops were planted during the R7 and R5 stage in soybean and corn, respectively in Barrett, MN. The cover crops established well in standing corn, however cover crop establishment failed in soybean.

b) Extension activities (Kandel, Wick, Franzen, Ransom, Wells, Nowatzki, Ripplinger, Lenssen)

The website was completed and is available at www.cropsyscap.org. Extension activities included 13 field days and tours, 4 workshops, 10 Café talks about cover crops, 11 extension publications, and numerous invited presentations or interviews.

4. Pinto bean response to winter rye cover crop, Carrington, ND 2017 (Endres, Ostlie)

A field study was initiated at the NDSU Carrington Research Extension Center with support from Northarvest Dry Bean Growers Association to examine the performance of pinto bean with winter rye grown as a cover or companion crop. Experimental design was a randomized complete block with four replications. The dryland trial was established on a Heimdal-Emrick loam soil. ‘ND Dylan’ rye was seeded in 7-inch rows at about 90 lb/A on September 20, 2016. ‘Lariat’ was direct planted into rye or rye residue (except tilled plots) in 21-inch rows on May 31, 2017 (Jday 151). Rye (tillering stage) was terminated by tillage (2x roto-till) on April 28 [33 days preplant (PP)] to establish a ‘check’ (treatment 1). Also, rye was PP terminated by glyphosate (0.77 lb ae/A) plus NIS+AMS (Class Act NG; 2.5% v/v) on May 1 followed by a second application of glyphosate (1 lb ae/A) on May 11 (treatment 2). Rye (boot stage) was late PP terminated by glyphosate (1 lb ae/A) on May 27 (treatment 3). Treatment 4 plots were land rolled on June 6 with rye in the flowering stage. Imazamox (0.03 lb ai/A) plus MSO (Destiny HC; 24 fl oz/A) and UAN (24 fl oz/A) was applied on June 26 [26 days after planting (DAP)] for terminating rye (dough stage) in treatments 4-5 and general weed control across trial. Herbicide treatments were applied with a hand-boom sprayer delivering 17 gpa through 80015 flat-fan nozzles at 35 psi. Pinto bean plants from treatments 1-3 were hand-pulled for field drying on October 6 and seed harvested with a plot combine on October 13. Plants from treatments 4-5 were pulled on October 13 and seed harvested on October 20.

Early PP rye termination had quicker plant emergence (5-8 days), flowering (7-21 days), and maturity (5-26 days) compared to late PP and POST rye termination (Table 1). Also, plants generally were taller, had a darker green color, and greater canopy closure with early PP rye termination versus later rye termination. With the exception of the early PP rye termination with herbicide, plant stand was similar among treatments. Seed yield was highest with early PP rye termination and lowest with POST rye termination. Test weight and seed size were similar among treatments with PP rye termination and greater than POST rye termination. The advantages with plant development, and seed yield with the early PP rye termination were likely due to greater soil moisture availability from reduced rye growth compared to the results with delaying rye termination, especially POST.

Grass control on July 10 (40 DAP) was excellent (96-99%) with PP glyphosate (trts 2-3), while broadleaf weed control was excellent (94-95%) with late PP glyphosate (trt 3) and delaying rye termination until 26 DAP (trts 4-5) (Table 2). With the exception of grass control with PP tillage (trt 1), grass and broadleaf control on July 24 (54 DAP) was excellent (92-97%) with POST imazamox plus rye residue among all treatments. Black medic emerged in the trial as a prominent weed during the growing season but was adequately controlled (84-93%) in trts 3-5, likely due to greater rye residue levels present compared to early PP terminated rye. Overall, trt 3 provided desirable control (84-99%) among all weeds in the trial.

Table 1. Pinto bean response to rye cover crop, Carrington, 2017.											
Treatment		Plant[b]							Seed		
No.	Rye termination method[a]	Emergence	Stand (12-Jun)	Height (3-Jul)	Color (3-Jul)	Flower (R1)	Canopy closure (4-Aug)	Maturity (R9)	Yield	Test weight	Count
		Jday	plt/A	cm	1 to 10	Jday	%	Jday	lb/A	lb/bu	no./lb
1	Tillage - early PP	160	49,960	25	2	200	75	263	2524	57.3	1123
2	Herbicide - early PP	161	58,181	23	4	201	73	256	2890	58.0	1133
3	Herbicide - late PP	166	43,636	15	6	208	58	268	2259	57.7	1192
4	Ground roll/POST herbicide	168	47,430	19	6	218	30	281	958	50.4	1365
5	POST herbicide	168	44,268	21	6	221	26	282	422	43.7	1320
mean		164	48,695	20	5	207	52	270	2024	54.7	1221
CV (%)		0.4	12.9	13.5	9.7	0.7	9.1	2.6	18.7	6.3	4.8
LSD (0.05)		1	9645	4	1	2	7	11	606	5.5	92

[a]Trts 1 and 2=April 28; Trt 3=May 27; Trts 4 and 5=June 26.

[b]Jday: 164=June 13; 207=July 26; 270=Sep 27. Plant stage at stand count = VC-2.

Table 2. Weed control with rye cover crop in pinto bean, Carrington, 2017.						
Treatment		Weed control[b]				
		10-Jul		24-Jul		
No.	Rye termination method[a]	Grass	Broadleaf	Grass	Broadleaf	Black medic
		%				
1	Tillage - early PP	73	74	79	95	63
2	Herbicide - early PP	97	76	97	94	69
3	Herbicide - late PP	99	95	92	97	84
4	Ground roll/POST herbicide	71	94	92	94	90
5	POST herbicide	67	94	94	94	93
mean		81	86	91	95	64
CV (%)		2.2	6.4	4.6	4.1	8.0
LSD (0.05)		3	8	6	NS	9

[a]Trts 1 and 2=April 28; Trt 3=May 27; Trts 4 and 5=June 26. Treatments 1-3 also received POST herbicide on June 26 for general weed control.

[b]Grass=rye, and green and yellow foxtail; Broadleaf=black medic (July 10 evaluation), common lambsquarters, common purslane, dandelion, redroot pigweed, shephardspurse, and wild buckwheat .

5. Interseeding legumes with hard red spring wheat- 2017, Carrington, ND (Aberle)

Tillage	Plant height	Moisture	Kernel weight	Test weight	Protein	Grain yield	Legume stand
	cm	%	g	lbs/bu	%	bu/A	Plants/acre
No-Till	68.6	13.4	25.3	60.3		36.7	5
Conventional Tillage	78.1	14.1	26.4	62.5	15.7	48.9	13
Trial Mean	73	14	26	61	16	43	9
C.V.%	9.3	5.0	5.1	2.9	6.6	17.6	70
LSD 5%	3.7	0.4	0.7	0.9	NS	4.0	4

Treatment	Plant height	Moisture	Kernel weight	Test weight	Protein	Grain yield	Legume stand
	cm	%	g	lbs/bu	%	bu/A	Plants/acre
Alsike clover interseeded	71.2	13.8	25.5	61.0	15.9	40.8	3
No legume interseeded	74.9	14.0	26.1	60.9	15.8	44.3	3
Subterranean clover interseeded	73.8	13.7	25.9	62.0	15.5	42.9	14
Sweet clover interseeded	73.6	13.5	25.8	61.7	15.4	43.3	15
Trial Mean	73	14	26	61	16	43	9
C.V.%	9.3	5.0	5.1	2.9	6.6	17.6	70
LSD 5%	NS	NS	NS	NS	NS	NS	5

Treatment		Plant height	Moisture	Kernel weight	Test weight	Protein	Grain yield	Legume stand
		cm	%	gm	lbs/bu	%	bu/A	Plants/acre
No-till	Alsike clover interseeded	67.4	13.1	25.1	60.0		35.1	3
No-till	No legume interseeded	68.3	14.2	26.2	60.0		38.0	6
No-till	Subterranean clover interseeded	69.8	13.2	24.9	60.9		37.1	2
No-till	Sweet clover interseeded	69.0	13.1	24.9	60.3		36.8	8
Conventional tillage	Alsike clover interseeded	75.0	14.6	26.0	62.0	15.9	46.5	3
Conventional tillage	No legume interseeded	81.5	13.9	26.1	61.8	15.8	50.7	0
Conventional tillage	Subterranean clover interseeded	77.8	14.2	26.9	63.1	15.5	48.7	27
Conventional tillage	Sweet clover interseeded	78.1	13.9	26.7	63.0	15.4	49.9	22
Trial mean		73	14	26	61	16	43	9
C.V.%		9.3	5.0	5.1	2.9	6.6	17.6	70
LSD 5%		NS	NS	NS	NS	NS	NS	7

5. 2017 Barley Cover Crop Timing Trial at Carrington (Aberle)

Cover Crop Treatment	Cover crop planting date	Test weight	Protein	Yield	Cover crop Biomass
		lbs/bu	%	bu/A	lbs/A
No cover crop	--	45.4	12.1	90.8	534
CC planted with Barley	5/5/17	44.1	12.5	88.1	1112
CC broadcast into 4-5 leaf Barley	6/1/17	44.4	12.4	98.6	987
CC drilled into 4-5 leaf Barley	6/1/17	44.3	12.4	89.4	926
CC broadcast over early headed Barley	6/30/17	44.9	12.0	97.8	872
CC planted after Barley harvest	8/11/17	43.8	12.3	85.0	818
Trial Mean		44.5	12.3	91.6	875
C.V.%		2.3	4.1	10.4	28
LSD 5%		NS	NS	NS	365

Barley Variety: Pinnacle
Planting Date: 5/5/17: Harvest Date: 9/8/17
Cover Crop Mix: turnip, radish, lentil and flax
Previous Crop: corn silage
Soil Type: Heimdal Silt Loam
Cover crop biomass includes all green above ground plant material at the end of the growing season. Data was collected on Oct. 16 and reported on a dry weight basis.

6. Barley Cover Crop Trial-2017 at Minot, ND (Aberle)

Cover Crop Treatment	Cover crop planting date	Days to head	Plant height	Lodging	% Plump	% Thin	1000 KWT	Test weight	Protein	Grain yield	Cover crop Biomass[3]
		DAP[1]	inches	0-9[2]	>6/64	<5/64	g	lbs/bu	%	bu/A	lbs/A
No cover crop	--	54	26	0	97	3	52	47.6	10.9	77.0	68
CC planted with barley	May 10	54	24	0	97	3	54	46.6	11.0	67.5	1483
CC broadcast over 4 leaf barley	May 30	54	24	0	98	2	55	48.3	11.1	70.1	562
CC broadcast over early headed barley	July 5	54	24	0	98	2	53	47.9	11.0	69.0	439
CC planted after barley harvest	Aug. 15	54	25	0	97	2	52	47.6	10.8	70.1	216
CC planted with barley + flax post-harvest	5/10 + 8/15	54	26	0	97	3	53	47.9	10.8	68.1	850
Trial Mean		54	25	0	97	2	53	47.6	10.9	70.3	1078
C.V.%		0.0	4.9	0	0.9	27	42.0	2.9	4.1	8.5	66.0
LSD 0.05		NS	NS	NS	NS	NS	NS	NS	NS	NS	1073

[1]DAP = Days after planting.
[2]Lodging: 0 = none, 9 = lying flat on the ground.
[3]Cover crop biomass includes all green plant material (cover crop + volunteer barley) at the end of the growing season. Data was collected on Oct. 13 and reported on a dry weight basis.

Barley Variety: Tradition
Planting Date: May 10
Harvest Date: August 14
Cover Crop Mix: turnip, radish, lentil and flax
Previous Crop: soy
Tillage System: No-till
Soil Type: Williams Loam
Note: Excellent sub-soil moisture but little in-season rainfall hindered germination of broadcast cover crops.

7. Spring wheat plant-back onto barley + cover crop stubble-2017, Carrington (Aberle)

Cover crop treatments	Days to head	15-Jul NDVI	Plant height	Test weight	Protein	Grain yield
	DAP[1]	0 - 1	inches	lbs/bu	%	bu/A
No cover crop	60	0.40	26	61.0	13.0	30.5
CC planted with barley	59	0.39	25	61.0	13.1	35.8
CC broadcast over 4 leaf barley	60	0.42	25	61.6	13.0	36.1
CC broadcast over early headed barley	60	0.37	25	60.4	12.9	29.0
CC planted after barley harvest	60	0.40	24	60.9	13.0	34.3
CC planted with barley + flax post-harvest	59	0.40	27	60.8	13.1	35.3
Trial Mean	60	0.40	25	61.0	13.0	33.5
C.V.%	2.3	13.90	8.2	1.2	7.9	11.5
LSD 5%	NS	NS	NS	NS	NS	NS

[1]DAP = Days after planting.
NS = no statistical difference between cover crop treatments.
Planting Date: April 21
Variety: Barlow:
Harvest Date: August 14
Notes: The trial did not receive any applied fertilizer. The Trial sustained moderate drought stress.

8. Effect of long-term integrated crop and livestock systems on forage finishing, soil fertility, nitrogen mineralization, carbon sequestration, and profitability (Landblom)

Minimizing reliance on harvested feeds through grazing and extending the grazing season beyond that which is typical in western ND is a management strategy that enhances economic and environmental stability, especially when grazing is integrated into a diverse crop rotation. Systems integration in the project identified that labor and inputs were reduced, soil fertility and crop yield improved, delayed feedlot entry of yearlings reduced days on feed and increased profitability, cow winter feed cost was reduced 2.8 times, and quality of life improved. Consumer demand for forage-finished beef is increasing by 25-30% per year and integrating forage-finished beef with fiber-based supplementation into the established crop rotation is a logical research succession, which needs to be continued to capture the long-term effect of integration on forage-finished beef grazing management, soil quality, nitrogen mineralization, carbon sparing, profitability, and farm family quality of life. The previous project established baseline soil bulk density, OM levels, seasonal soil nitrate-N fertility and end of season ammonium-N and nitrate-N levels. Since soil dynamics change slowly, extending the integrated research into years 7-9, is relevant to measure grazed and ungrazed soil quality dynamics in much greater detail. That is, maintenance of short and long-term carbon pools, water soluble soil organic nitrogen, seasonal soil NO3-N fertility, residual soil nitrogen pools, microbial CO_2-C and soil C:N ratio change between crops within the rotation, soil GHG emissions, soil bulk density change, and soil water dynamics. On-farm cooperator demonstration projects will facilitate learning by evaluating perennial and annual forage sequence grazing for forage-finishing yearling steers on one farm and extended grazing for marketing heavy yearling steers on another. Two other farmer demonstrations will extend the winter grazing season after weaning grazing cover crops and corn on one farm and grazing cover crops followed by bale-grazing on another farm. Research data measuring long-term effects and on-farm cooperator projects will coalesce into a combined effort to increase awareness for agricultural and non-agricultural stakeholders providing a better understanding of integrated production principles, logistics, and economics. Response surveys will be used to evaluate producer awareness and willingness to implement. Outreach programming will blend traditional extension and journal publication methods with yearly NCR SARE multi-state webinars, community café meetings, forage-finishing beef production workshops, field walks, high school student field days, exercise-health-service group presentations, YouTube (How-To) videos, DVD documentary, and social media outreach to schedule events, post links, inform, educate, and measure internet response.

IMPACT STATEMENT

Cover crops adoption in North Dakota is increasing exponentially thanks to the many researchers involved in cover crops in the state. The positive impact to the environment will not be measurable until a few more years, but we are positive it will occur.

<u>Evaluation of extension impacts (Kandel, Wick)</u>

Train the Trainer impacts – the domino effect

According to survey respondents, 81% of whom rated the workshops very or extremely useful. Key findings from the survey include: (i) 97% of respondents used what they learned at these three workshops to create cover crop activities in their part of the state, (ii) 91% shared what they learned with their colleagues, and (iii) 89% shared what they learned with farmers

Farmer impacts and outcomes – changes in attitudes and behavior

The greatest change in behavior among respondents was establishing a cover crop after harvest of a cash crop (50%) and using cover crops for soil erosion control (51%). The greatest potential for adoption of new practices included establishing a cover crop in a standing cash crop (51%) and interseeding at the time of side-dressing N into corn (50%).