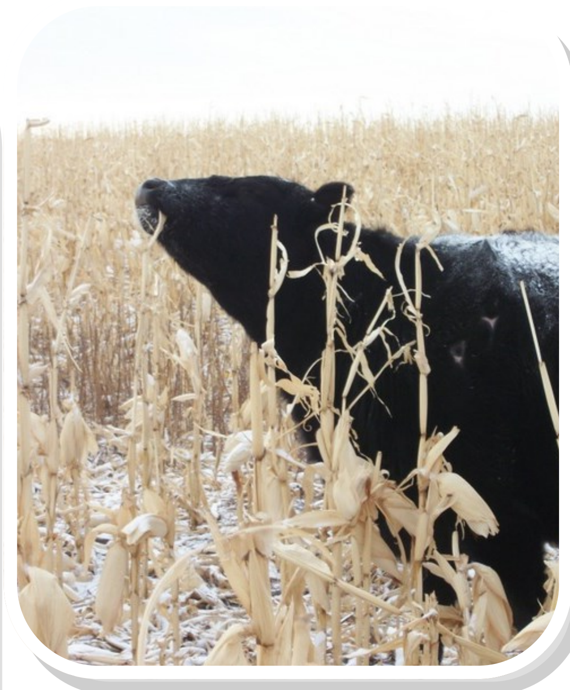

North Dakota State University

Hettinger Research Extension Center

2013 Annual Report

NDSU | HETTINGER RESEARCH EXTENSION CENTER

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NORTH DAKOTA AGRICULTURE EXPERIMENT STATION

Hettinger Research Extension Center

Hettinger REC Research in Brief

- Integrated crops, livestock, and range research
- Variety, herbicide, and crop production research
- Lamb and beef feedlot nutrition and management
- Reproductive management of fall, winter, and spring lambing ewes
- Alternative, co-product, and "Natural" feeds for ruminants
- Multiple-land use management including cropping systems, livestock, and wildlife as potential outputs
- Range monitoring techniques

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The Hettinger Research Extension Center (HREC) was established from a gift of 160 acres by the residents of Adams County and the city of Hettinger in 1909. Original work at the HREC involved converting native prairie to farm land for the purpose of agronomic research. In 1912, through cooperation with the United States Department of Agriculture, a dry land farming trial began. In 1913 a herd of Guernsey and Jersey cows and bulls was purchased to aid local producers in the production of replacement dairy cattle. Following a brief closure during the Depression, the HREC continued to grow the research programs, focusing on agronomy and sheep breeding. In 1947, an option was secured for the purchase of an extra quarter of land to continue and expand sheep and agronomy research. In the 1980's the research programs were solidified with the addition of land bringing the total owned land to 1130 acres, and the hiring of an agronomist.

The HREC is a semi-arid site located in southwest North Dakota, providing the most southerly NDSU location in the non-glaciated portion of North Dakota as a site for its agronomy research program. The HREC also is located at the center of the North Dakota sheep industry, the focus of one of its animal research programs. Furthermore, the HREC is located in an area of rapidly growing livestock feeding ventures, another focus of animal research at the HREC. Additionally, the HREC is located in a region where much of the land base is in the Conservation Reserve Program and Forest Service lands, which has resulted in additional research evaluating potential changes in the CRP program and how these changes may affect upland native and game bird populations. A new research program evaluating low-cost rangeland monitoring strategies on U.S. Forest Service lands has resulted in a significant increase in the quantity of rangeland, livestock, and wildlife interaction research conducted at the HREC throughout the western Dakotas. Research at HREC involves the disciplines of animal science, range and wildlife science and agronomy. Collaboration is with Main Station scientists, Branch Station scientists, U.S. Forest Service, grazing associations, university scientists from WY, SD, and MT, and USDA research entities in these research disciplines to improve the productivity of livestock and cropping systems and economic development of the region. Through these efforts, the center's research program has gained a national reputation for its involvement with sheep production systems as well as a strong regional and state reputation for its research in agronomy, multiple-land use, and calf backgrounding.

AGRONOMY

- Distributed foundation seed produced at NDSU research centers, making new varieties available to southwest North Dakota producers.

- Conducted crop variety, forage, plant disease, and herbicide trials as well as off-station variety testing at Regent, Scranton, New Leipzig, Selfridge, and Mandan.
- Conducted biofuel trial in conjunction with other REC's.
- Evaluate new varieties and technologies for drought tolerant corn and wheat and preventing damage from wheat stem sawfly.

RANGE AND LIVESTOCK

- Began a multi-agency and discipline research project evaluating the reclamation of grazing lands inhabited by prairie dogs on the Standing Rock Sioux Reservation.
- Started new project evaluating rangeland restoration and wildlife habitat opportunities on the Elkhorn Ranch near Medora, ND.
- Evaluated the use of cover crops for soil health benefits and for fall grazing of pregnant ewes.

HREC Crops, Livestock and Range

- Conducted multiple research projects evaluating environmental and economic consequences of multiple-use management of agricultural lands in the Northern Great Plains including nesting success of upland birds, and telemetry of upland chicks.

- Continued research in “Value Added Animal Production”; a research program focused on evaluating forage, grain, byproduct, and marketing alternatives in calf backgrounding and lamb finishing.

- Evaluated supplementation strategies during pregnancy and their effect on embryonic death loss, fetal development, and potential feedlot and reproductive performance of offspring.

- Conduct the Dakota Fall Performance Ram Test; a 140 day Rambouillet Certificate of Merit program, one of three Rambouillet Ram Tests in the nation.

OUTREACH

- Conduct annually the HREC Beef Day, Sheep School, Shearing School, Wool Classing School, Carcass Ultrasound School, Crops Tours, Crops Day, and Sportsmen's Night Out.

- Published “Importance of Range Monitoring” video.

- Published NDSU Sheep Research Report and Hettinger Crops Day Report and contributed to NDSU Beef and Range Report and Feedlot Research Report.

HREC Research Faculty

Dr. Christopher Schauer, Director & Animal Scientist
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NDSU | HETTINGER RESEARCH EXTENSION CENTER

Weather Summary - Hettinger

Frost Free Days

	28°F	32°F	Normal 32°F
Date of Last Frost	May 11	May 11	May 18
Date of First Frost	October 5	October 4	September 20
Frost Free Days	**147**	**146**	**125**

Precipitation (inches)

Month	2008-09	2009-10	2010-11	2011-12	2012-13	58 Year Average
October	2.4	2.3	0.4	0.8	0.7	1.1
November	2.6	0.0	0.6	0.0	0.1	0.5
December	0.6	2.0	0.6	0.2	0.5	0.3
January	0.3	0.3	1.1	0.4	0.2	0.4
February	1.8	0.2	1.0	0.5	0.2	0.4
March	3.1	0.7	0.7	0.2	0.2	0.7
April	1.1	1.8	2.3	3.0	0.2	1.6
May	1.4	3.7	4.6	2.2	7.9	2.6
June	3.5	2.9	3.4	2.4	3.7	3.3
July	2.2	3.7	1.9	3.9	2.0	2.0
August	3.5	2.4	2.3	2.2	1.8	1.7
September	0.4	3.2	0.4	0.0	3.4	1.4
April-Sept.	**12.1**	**17.8**	**14.8**	**13.7**	**19.0**	**12.7**
Total	**22.8**	**23.2**	**19.2**	**15.7**	**20.7**	**16.2**

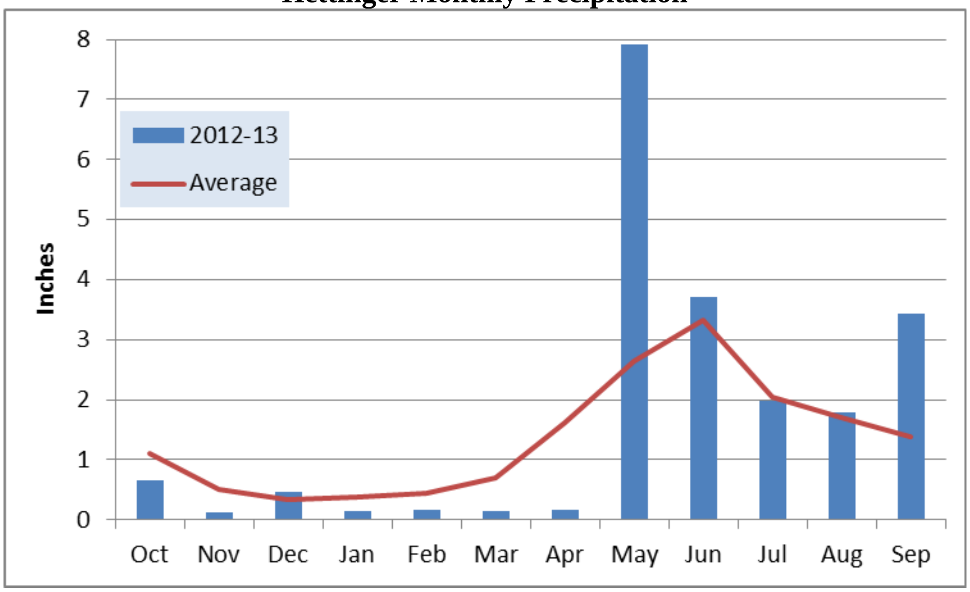
Air Temperature (°F)

Month	2008-09	2009-10	2010-11	2011-12	2012-13	58 Year Average
October	44.9	36.8	48.5	48.2	42.1	45.6
November	32.0	36.9	28.0	30.9	32.4	30.0
December	11.2	9.5	13.4	23.9	18.5	19.7
January	14.8	13.6	12.7	24.2	18.3	15.2
February	18.8	11.7	14.7	21.8	26.7	20.0
March	22.4	31.2	22.8	44.4	27.4	28.8
April	38.2	44.8	39.4	46.9	35.5	42.6
May	52.0	50.0	50.2	53.6	53.5	53.7
June	58.8	62.0	62.0	66.5	61.7	63.1
July	64.6	67.6	71.3	75.2	68.1	70.1
August	63.0	68.6	65.3	67.8	69.5	68.7
September	62.6	56.3	56.9	59.4	62.5	57.8
Average	**40.3**	**40.7**	**40.4**	**46.9**	**43.0**	**42.9**

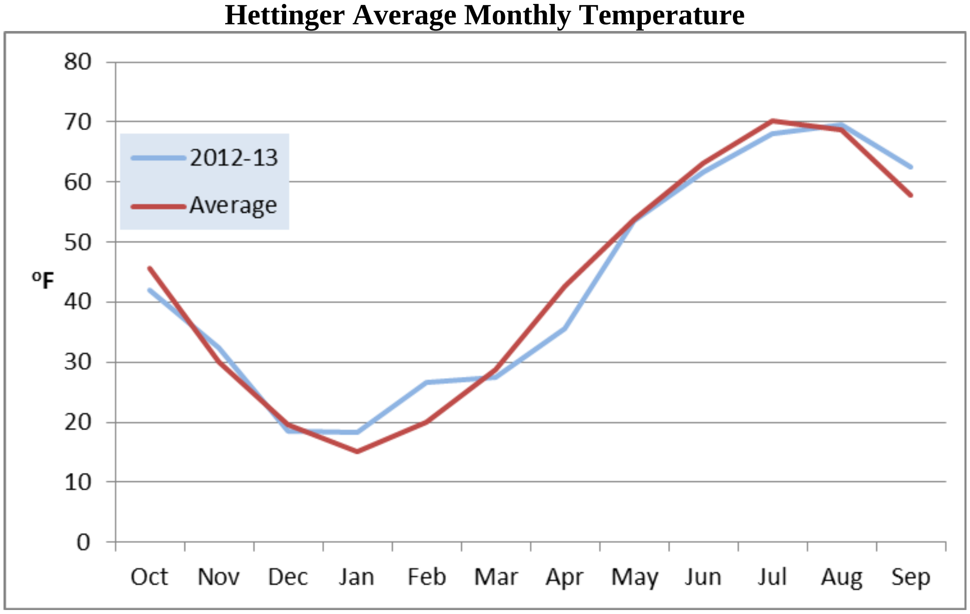
Corn Growing Degree Days (GDD)

Month	2009	2010	2011	2012	2013	41 Year Average
May	265	210	161	266	266	260
June	344	393	358	498	381	418
July	458	536	631	688	543	586
August	461	547	555	504	553	537
September	421	278	347	411	403	320
Total	**2006**	**2032**	**2052**	**2367**	**2146**	**2121**

Hettinger Monthly Precipitation



Hettinger Average Monthly Temperature



Hard Red Spring Wheat										Hettinger, ND
	Days to	Plant	Plant	Test	Grain	----- Grain Yield -----			Average Yield	
Variety	Head	Height	Lodge	Weight	Protein	2011	2012	2013	2 yr	3 yr
	*	inches	0-9**	lbs/bu	%	------------- Bushels per acre -------------				
SY 605CL	67	36	0	63.1	16.2	51.7	80.3	71.8	76.1	67.9
SY Soren	69	32	0	63.0	15.7	48.8	82.2	72.2	77.2	67.7
Samson	69	31	0	61.2	15.0	53.2	79.2	70.4	74.8	67.6
Advance	69	33	4	63.0	14.4	49.0	84.9	67.8	76.4	67.2
Brennan	67	30	1	63.2	16.0	49.9	79.9	69.8	74.8	66.5
WB-Digger	69	37	1	61.8	15.2	38.6	83.5	75.8	79.6	66.0
Velva	70	37	0	59.1	15.8	49.0	79.1	68.0	73.6	65.4
Sabin	70	35	2	62.6	15.9	47.5	82.7	65.4	74.1	65.2
Elgin-ND	71	40	0	61.5	16.2	50.1	77.0	66.7	71.8	64.6
Breaker	70	36	0	61.3	15.4	44.2	76.2	69.0	72.6	63.1
Howard	68	37	1	62.3	15.7	46.1	73.0	69.9	71.4	63.0
Jenna	72	34	0	61.4	15.3	48.9	72.0	67.7	69.8	62.9
SY Tyra	72	30	0	61.8	14.3	39.0	82.5	66.0	74.3	62.5
Forefront	67	39	1	62.8	15.9	46.0	75.7	64.9	70.3	62.2
Linkert	70	30	0	62.4	16.8	45.0	80.4	61.0	70.7	62.1
Norden	69	33	0	62.8	15.3	43.4	76.5	65.8	71.2	61.9
Barlow	68	37	0	62.2	16.1	45.5	71.5	68.2	69.8	61.7
Select	66	36	0	63.6	15.2	44.7	73.1	66.0	69.6	61.3
WB-Mayville	68	30	0	61.4	16.0	41.6	76.6	62.6	69.6	60.3
Prosper	70	36	0	61.3	14.9	40.0	76.6	63.0	69.8	59.9
Rollag	68	32	0	63.0	16.4	35.2	80.4	63.9	72.2	59.8
Steele-ND	70	36	1	61.6	15.2	38.6	72.2	67.3	69.7	59.4
RB07	67	33	0	61.9	16.0	35.8	79.5	62.7	71.1	59.3
Mott	72	39	0	60.6	16.2	39.3	73.2	65.0	69.1	59.2
Glenn	67	37	0	63.1	17.2	39.5	71.4	60.2	65.8	57.0
Vantage	74	34	0	60.8	17.8	37.8	67.6	60.0	63.8	55.1
ND 901 CL Plus	68	36	0	61.7	17.4	38.9	69.0	55.7	62.4	54.5
Faller	70	35	0	59.7	15.0	38.0	68.8	54.4	61.6	53.7
WB-Gunnison	69	32	1	60.4	14.6	30.3	70.3	51.8	61.1	50.8
SY-Rowyn	69	32	0	62.0	14.8	--	83.7	69.5	76.6	--
LCS Albany	71	35	0	61.5	14.4	--	--	75.7	--	--
MS Stingray	72	36	0	60.4	13.7	--	--	70.9	--	--
LCS Powerplay	70	34	1	62.9	15.0	--	--	69.8	--	--
LCS Breakaway	68	32	0	63.9	15.8	--	--	69.6	--	--
Trial Mean	69	35	0	62.0	15.7	42.1	75.9	66.1	--	--
C.V. %	1.4	3.0	217.8	0.9	2.5	6.6	4.6	5.6	--	--
LSD 10%	1	1	1	0.6	0.5	3.5	4.1	4.3	--	--

* Days to Head = the number of days from planting to head emergence from the boot.

** 0 = no lodging, 9 = 100% lodged.

Planting Date: April 23

Harvest Date: August 19

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Spring Wheat Green Fallow

Hard Red Spring Wheat - 2013 Scranton, ND

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Advance	29	3	60.8	14.4	--	--	54.3	--	--
Barlow	35	2	59.8	16.3	34.5	48.9	61.9	55.4	48.4
Elgin-ND	34	1	59.3	15.8	--	58.2	61.6	59.9	--
Faller	31	2	58.6	14.7	28.0	41.1	55.1	48.1	41.4
Forefront	33	2	61.6	15.8	--	--	53.3	--	--
Glenn	34	2	61.1	16.2	27.8	50.7	55.2	52.9	44.6
Mott	35	0	60.6	15.9	34.3	43.3	63.7	53.5	47.1
Prosper	32	2	59.3	14.7	28.9	44.0	57.3	50.7	43.4
RB07	31	3	61.7	16.0	33.0	51.3	57.1	54.2	47.1
Sabin	31	3	61.0	15.3	35.5	49.4	53.5	51.4	46.1
Select	34	4	62.7	15.1	29.9	51.2	56.4	53.8	45.8
SY Soren	27	1	61.1	16.3	29.7	53.1	55.7	54.4	46.2
Velva	32	1	56.3	15.8	31.5	50.1	66.4	58.2	49.3
Trial Mean	32	2	60.3	15.6	28.7	49.3	57.8	--	--
C.V. %	3.6	35.7	2.3	1.7	5.2	5.8	8.0	--	--
LSD 10%	1	1	1.6	0.3	1.6	3.4	5.5	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: April 29

Harvest Date: August 21

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Flax

Hard Red Spring Wheat - 2013 **Regent, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Advance	31	4	60.6	15.2	--	--	65.1	--	--
Barlow	36	3	60.5	16.6	30.4	51.1	67.4	59.2	49.6
Elgin-ND	37	2	59.6	16.5	--	60.9	73.8	67.3	--
Faller	34	2	59.8	15.4	34.3	43.0	68.3	55.6	48.5
Forefront	40	3	62.2	16.2	--	--	71.8	--	--
Glenn	37	3	63.3	17.1	27.0	53.0	62.5	57.8	47.5
Mott	38	0	60.6	16.9	33.8	45.2	69.9	57.6	49.6
Prosper	34	3	60.1	15.1	30.0	46.0	71.4	58.7	49.1
RB07	33	4	61.1	16.0	35.2	53.6	69.0	61.3	52.6
Sabin	35	4	60.6	16.0	32.7	51.6	70.2	60.9	51.5
Select	35	4	62.2	15.1	35.4	53.5	72.1	62.8	53.7
SY Soren	29	4	60.9	16.7	34.8	55.5	72.6	64.0	54.3
Velva	33	0	58.4	16.8	34.9	52.4	73.3	62.8	53.5
Trial Mean	35	3	60.8	16.1	31.2	51.5	69.8	--	--
C.V. %	3.6	27.0	0.8	1.6	5.4	5.8	5.7	--	--
LSD 10%	1	1	0.6	1.6	1.8	3.5	4.8	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: April 29

Harvest Date: August 21

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Canola

Hard Red Spring Wheat - 2013 **New Leipzig, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012**	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Advance	29	3	59.9	14.2	--	--	55.5	--	--
Barlow	32	2	59.3	15.8	15.6	--	57.7	57.7	--
Elgin-ND	34	2	57.9	16.3	--	--	59.2	--	--
Faller	31	2	56.7	15.1	15.6	--	53.5	53.5	--
Forefront	35	2	60.9	15.8	--	--	60.3	--	--
Glenn	33	2	60.1	16.4	13.5	--	57.6	57.6	--
Mott	33	0	58.4	16.2	23.6	--	64.4	64.4	--
Prosper	31	2	56.2	15.2	15.7	--	56.7	56.7	--
RB07	29	3	59.4	16.0	19.7	--	56.2	56.2	--
Sabin	30	2	59.1	15.4	23.2	--	54.3	54.3	--
Select	33	3	61.8	15.0	22.2	--	63.2	63.2	--
SY Soren	28	3	59.4	16.4	14.2	--	59.4	59.4	--
Velva	30	1	55.8	15.9	17.1	--	65.9	65.9	--
Trial Mean	31	2	58.8	15.7	17.1	--	58.8	--	--
C.V. %	3.9	27.7	1.6	2.4	9.0	--	7.9	--	--
LSD 10%	1	1	1.1	0.5	2.2	--	5.5	--	--

* 0 = no lodging, 9 = 100% lodged.

** Location was not planted in 2012.

Planting Date: May 2

Harvest Date: August 21

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Sunflower

Hard Red Spring Wheat - 2013 **Selfridge, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012**	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Advance	32	2	60.0	16.4	--	--	63.1	--	--
Barlow	35	1	59.4	17.7	33.3	--	57.7	57.7	--
Elgin-ND	37	2	57.4	18.5	--	--	61.9	--	--
Faller	34	2	57.3	17.0	32.7	--	61.1	61.1	--
Forefront	38	2	58.9	18.9	--	--	57.8	--	--
Glenn	37	2	60.9	18.6	31.6	--	57.2	57.2	--
Mott	38	0	57.6	18.5	26.7	--	61.3	61.3	--
Prosper	34	2	58.0	17.6	33.7	--	63.5	63.5	--
RB07	33	2	57.9	18.4	30.3	--	63.1	63.1	--
Sabin	34	2	58.9	17.4	36.4	--	64.1	64.1	--
Select	37	2	60.6	17.5	34.5	--	58.4	58.4	--
SY Soren	31	0	58.9	18.4	26.5	--	58.6	58.6	--
Velva	34	1	57.4	18.0	30.6	--	60.2	60.2	--
Trial Mean	35	1	58.7	17.9	30.2	--	60.6	--	--
C.V. %	2.5	28.3	0.9	2.4	6.4	--	6.5	--	--
LSD 10%	1	1	0.6	0.5	3.3	--	4.7	--	--

* 0 = no lodging, 9 = 100% lodged.

** Location was not harvested in 2012.

Planting Date: May 2

Harvest Date: August 26

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Corn

Hard Red Spring Wheat - 2013 — Mandan, ND

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011**	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Advance	32	2	60.0	13.7	--	--	70.3	--	--
Barlow	35	2	60.9	15.2	--	71.2	72.4	71.8	--
Elgin-ND	38	2	59.4	15.4	--	69.1	78.1	73.6	--
Faller	36	3	60.6	14.2	--	64.5	76.9	70.7	--
Forefront	38	1	60.2	15.5	--	--	78.2	--	--
Glenn	38	1	61.2	15.7	--	65.4	70.8	68.1	--
Mott	38	2	60.1	15.1	--	69.1	75.0	72.0	--
Prosper	37	3	60.1	13.7	--	68.1	71.9	70.0	--
RB07	33	1	59.9	14.7	--	69.0	72.3	70.7	--
Sabin	37	2	59.8	15.2	--	77.4	79.7	78.5	--
Select	36	1	61.1	14.7	--	75.7	70.9	73.3	--
SY Soren	31	2	59.4	15.6	--	77.1	76.9	77.0	--
Velva	35	1	60.0	14.8	--	70.2	71.9	71.1	--
Trial Mean	36	2	60.2	14.9	--	70.0	74.3	--	--
C.V. %	2.9	51.9	1.8	3.1	--	3.1	7.3	--	--
LSD 10%	1	1	1.3	0.5	--	2.6	6.5	--	--

* 0 = no lodging, 9 = 100% lodged.

** Location was not harvested in 2011

Planting Date: May 2

Harvest Date: August 26

Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).

Previous Crop: Spring Wheat

Durum Wheat										**Hettinger, ND**
	Days to	Plant	Plant	Test	Grain	----- Grain Yield -----			Average Yield	
Variety	Head	Height	Lodge	Weight	Protein	2011	2012	2013	2 yr	3 yr
	*	inches	0-9**	lbs/bu	%	------------- Bushels per acre -------------				
Joppa	73	39	2	61.0	12.4	46.8	66.8	51.1	59.0	54.9
DG Max	72	38	2	62.7	13.6	39.0	69.9	53.9	61.9	54.3
Ben	71	41	2	62.1	13.5	37.2	62.5	53.2	57.9	51.0
Tioga	70	39	4	62.9	12.5	28.1	64.2	59.9	62.1	50.7
Rugby	72	42	2	62.1	13.0	40.1	60.3	51.3	55.8	50.6
CDC Verona	74	39	0	59.6	14.2	35.2	60.5	55.6	58.1	50.4
Alkabo	73	37	1	61.4	12.7	34.8	64.9	50.5	57.7	50.1
AC Commander	72	31	3	60.2	13.6	33.5	72.9	43.7	58.3	50.0
Strongfield	73	38	2	61.2	14.3	28.0	66.4	52.4	59.4	48.9
Lebsock	72	38	1	62.3	12.7	33.7	63.4	49.5	56.5	48.9
Pierce	74	38	2	61.2	13.2	35.9	62.9	47.2	55.1	48.7
Grenora	72	37	2	61.1	13.1	34.6	58.3	52.6	55.5	48.5
Carpio	74	38	3	59.8	12.7	35.0	59.6	50.3	54.9	48.3
Mountrail	72	38	3	61.1	12.3	34.5	53.6	55.3	54.4	47.8
Divide	72	38	2	62.4	13.4	30.5	56.7	55.1	55.9	47.4
AC Navigator	72	31	3	61.3	13.5	26.4	73.2	42.3	57.8	47.3
Maier	74	37	2	61.1	14.4	34.4	64.8	42.3	53.6	47.2
Alzada	70	28	5	60.0	13.2	28.9	69.6	35.0	52.3	44.5
VT Peak	71	37	3	63.5	12.9	--	--	63.3	--	--
Trial Mean	72	38	2	62.0	13.0	37.7	64.5	56.0	--	--
C.V. %	3.9	1.0	36.4	0.9	2.1	5.7	4.9	7.0	--	--
LSD 10%	2	1	1	0.6	0.3	3.0	3.7	4.6	--	--

* Days to Head = the number of days from planting to head emergence from the boot.

** 0 = no lodging, 9 = 100% lodged.

Planting Date: April 23

Harvest Date: August 19

Seeding Rate: 1.2 million live seeds / acre.

Previous Crop: Spring Wheat Green Fallow

Durum Wheat -2013 — Scranton, ND

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Alkabo	35	4	59.6	12.4	31.4	50.4	52.9	51.7	44.9
Carpio	36	5	58.5	12.4	32.9	50.2	54.6	52.4	45.9
Divide	38	5	61.5	12.9	32.1	49.5	57.5	53.5	46.4
Grenora	34	5	59.7	12.9	31.9	44.1	53.3	48.7	43.1
Joppa	37	5	59.8	12.1	31.6	51.5	61.2	56.4	48.1
Mountrail	35	4	59.1	12.4	33.5	39.6	55.3	47.4	42.8
Tioga	39	5	62.1	12.3	32.9	50.4	60.7	55.6	48.0
Trial Mean	36	5	60.0	12.5	32.3	48.2	56.5	--	--
C.V. %	3.3	12.6	2.8	3.6	4.1	4.7	5.8	--	--
LSD 10%	1	1	2.1	0.6	NS	2.7	4.0	--	--

* 0 = no lodging, 9 = 100% lodged.
Planting Date: April 29
Harvest Date: August 21
Seeding Rate: 1.2 million live seeds / acre.
Previous Crop: Flax

Durum Wheat - 2013 — Regent, ND

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Alkabo	38	4	60.5	13.0	26.9	37.1	61.9	49.5	42.0
Carpio	40	4	59.6	13.3	30.9	30.1	64.5	47.3	41.8
Divide	39	3	60.7	14.0	26.9	33.5	65.5	49.5	42.0
Grenora	37	4	60.2	13.4	25.6	38.1	66.7	52.4	43.5
Joppa	39	4	60.6	12.7	32.6	40.7	69.7	55.2	47.7
Mountrail	39	3	59.2	12.9	26.3	28.8	64.9	46.9	40.0
Tioga	41	5	60.7	13.3	23.7	40.6	67.1	53.8	43.8
Trial Mean	39	4	60.2	13.2	27.3	36.0	65.8	--	--
C.V. %	2.3	14.8	0.8	2.0	6.9	5.4	5.9	--	--
LSD 10%	1	1	0.6	0.3	2.1	2.4	4.8	--	--

* 0 = no lodging, 9 = 100% lodged.
Planting Date: April 29
Harvest Date: August 21
Seeding Rate: 1.2 million live seeds / acre.
Previous Crop: Canola

Durum Wheat -2013	**Mandan, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2010	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
Alkabo	40	2	61.4	11.6	67.1	78.2	80.4	79.3	75.2
Carpio	42	3	62.1	11.5	69.0	80.2	79.8	80.0	76.3
Divide	42	3	61.4	12.4	69.2	76.9	77.1	77.0	74.4
Grenora	39	3	59.8	12.4	71.7	72.5	81.2	76.9	75.1
Joppa	41	2	61.3	11.3	--	82.0	86.4	84.2	--
Mountrail	40	2	60.6	11.7	70.0	57.1	84.6	70.8	70.6
Tioga	44	3	61.4	11.6	65.6	82.4	85.3	83.8	77.8
Trial Mean	41	3	61.2	11.8	68.8	75.4	82.1	--	--
C.V. %	3.5	17.4	0.5	4.3	4.1	3.3	4.1	--	--
LSD 10%	2	1	0.4	0.6	NS	3.0	4.1	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: May 2

Harvest Date: August 26

Seeding Rate: 1.2 million live seeds / acre.

Previous Crop: Spring Wheat

Barley	**Hettinger, ND**

Variety	Days to Head	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	*	inches	0-9**	lbs/bu	%	------------ Bushels per acre ------------				
TWO ROW										
Conlon	66	34	6	48.9	13.2	80.9	80.2	102.1	91.2	87.7
Rawson	69	36	2	46.2	11.7	66.7	87.3	116.1	101.7	90.0
Pinnacle	70	35	3	47.1	11.8	59.4	71.7	110.5	91.1	80.5
AC Metcalfe	73	37	2	46.1	14.9	56.8	54.7	87.4	71.1	66.3
CDC Copeland	73	39	3	45.2	12.7	63.4	79.0	103.5	91.3	82.0
Conrad	71	35	4	46.5	13.3	71.1	91.0	102.7	96.9	88.3
SIX ROW										
Celebration	70	36	6	44.2	13.8	70.2	99.5	110.7	105.1	93.5
Quest	70	39	3	43.5	13.3	72.3	90.6	114.0	102.3	92.3
Innovation	68	36	3	44.4	13.5	89.4	102.5	122.4	112.5	104.8
Lacey	71	37	3	46.4	13.6	84.1	91.0	116.5	103.8	97.2
Tradition	69	37	3	45.0	12.6	91.1	93.5	124.1	108.8	102.9
Stellar-ND	70	38	3	44.4	13.1	61.7	94.3	107.9	101.1	88.0
Trial Mean	70	36	3	45.8	12.7	76.6	91.0	115.5	--	--
C.V. %	4	0.9	36.0	1.4	3.5	6.8	5.1	5.6	--	--
LSD 10%	2	1	1	0.8	0.5	7.4	5.5	7.6	--	--

* Days to Head = the number of days from planting to head emergence from the boot.
** 0 = no lodging, 9 = 100% lodged.
Planting Date: April 23
Harvest Date: August 19
Seeding Rate: 750,000 live seeds / acre.
Previous Crop: Spring Wheat Green Fallow

Barley - 2013 **Scranton, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
TWO ROW									
Conlon	31	6	48.1	12.9	--	86.7	81.0	83.9	--
Rawson	33	3	48.3	12.2	30.0	81.1	92.5	86.8	67.9
Pinnacle	30	3	49.0	12.0	54.4	80.4	93.5	87.0	76.1
SIX ROW									
Celebration	29	6	46.7	13.6	--	85.1	82.6	83.9	--
Quest	35	6	46.3	13.0	54.6	72.5	94.6	83.6	73.9
Innovation	30	5	47.6	12.7	56.7	88.4	80.3	84.4	75.1
Trial Mean	31	5	47.7	12.7	50.3	82.4	87.4	--	--
C.V. %	4.9	17.7	1.2	4.3	3.1	5.0	9.6	--	--
LSD 10%	2	1	0.7	0.7	1.8	5.1	10.4	--	--

* 0 = no lodging, 9 = 100% lodged.
Planting Date: April 29
Harvest Date: August 21
Seeding Rate: 1.25 million live seeds / acre.
Previous Crop: Flax

Barley - 2013 **Regent, ND**

Variety	Plant Height	Plant Lodge	Test Weight	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	------------ Bushels per acre ------------				
TWO ROW								
Conlon	34	6	48.4	33.5	69.1	88.4	78.8	63.7
Rawson	35	3	48.0	39.5	48.8	107.6	78.2	65.3
Pinnacle	35	3	48.1	43.6	65.3	106.3	85.8	71.7
SIX ROW								
Celebration	33	6	45.4	--	52.4	98.9	75.7	--
Quest	36	6	45.1	42.2	50.9	95.9	73.4	63.0
Innovation	33	5	46.2	42.4	67.2	104.8	86.0	71.5
Trial Mean	34	5	46.9	40.1	58.9	100.3	--	--
C.V. %	4.6	17.7	0.8	6.6	6.2	4.5	--	--
LSD 10%	2	1	0.5	3.0	4.5	5.5	--	--

* 0 = no lodging, 9 = 100% lodged.
Planting Date: April 29
Harvest Date: August 21
Seeding Rate: 1.25 million live seeds / acre.
Previous Crop: Canola

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Barley - 2013 **New Leipzig, ND**

Variety	Plant Height	Plant Lodge	Test Weight	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	------------ Bushels per acre ------------				
TWO ROW								
Conlon	27	6	44.9	--	--	76.0	--	--
Rawson	32	3	45.4	--	--	90.5	--	--
Pinnacle	30	5	45.5	--	--	81.9	--	--
SIX ROW								
Celebration	30	5	42.3	--	--	90.1	--	--
Quest	31	4	43.2	--	--	92.4	--	--
Innovation	29	5	43.9	--	--	93.0	--	--
Trial Mean	30	5	44.2	--	--	87.3	--	--
C.V. %	5.0	21.7	0.9	--	--	7.9	--	--
LSD 10%	2	1	0.5	--	--	8.5	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: May 2

Harvest Date: August 21

Seeding Rate: 1.25 million live seeds / acre.

Previous Crop: Sunflower

Barley - 2013 **Selfridge, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2010	2011	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
TWO ROW									
Conlon	31	7	47.0	14.3	76.6	58.8	80.6	69.7	72.0
Rawson	32	4	45.4	13.4	74.2	44.6	83.7	64.2	67.5
Pinnacle	31	6	46.1	12.7	89.8	52.5	93.2	72.9	78.5
SIX ROW									
Celebration	32	8	43.0	16.8	--	--	74.6	--	--
Quest	34	7	43.0	14.9	--	43.4	81.5	62.5	--
Innovation	31	7	44.2	15.1	--	37.9	89.7	63.8	--
Trial Mean	32	6	44.8	14.5	81.7	47.9	83.9	--	--
C.V. %	4.6	9.7	1.2	3.9	4.3	10.4	5.4	--	--
LSD 10%	2	1	0.6	0.7	5.3	9.0	5.6	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: May 2

Harvest Date: August 26

Seeding Rate: 1.25 million live seeds / acre.

Previous Crop: Corn

Barley - 2013 **Mandan, ND**

Variety	Plant Height	Plant Lodge	Test Weight	Grain Protein	----- Grain Yield ----- 2010	2011	2013	Average Yield 2 yr	3 yr
	inches	0-9*	lbs/bu	%	------------ Bushels per acre ------------				
TWO ROW									
Conlon	32	6	45.6	13.0	79.5	41.9	59.7	50.8	60.4
Rawson	33	4	46.0	11.9	89.4	43.1	88.0	65.6	73.5
Pinnacle	36	6	45.8	11.2	86.5	45.9	90.8	68.4	74.4
SIX ROW									
Celebration	34	5	43.8	14.7	90.1	36.6	41.9	39.3	56.2
Quest	36	5	44.1	12.7	--	49.8	78.7	64.3	--
Innovation	33	5	44.6	12.9	--	51.4	57.0	54.2	--
Trial Mean	34	5	45.0	12.7	87.5	44.8	69.4	--	--
C.V. %	5.4	7.2	0.8	2.4	2.7	5.6	12.0	--	--
LSD 10%	2	1	1.8	0.4	2.6	3.1	10.3	--	--

* 0 = no lodging, 9 = 100% lodged.

Planting Date: May 2

Harvest Date: August 26

Seeding Rate: 1.25 million live seeds / acre.

Previous Crop: Spring Wheat

Oat	**Hettinger, ND**

Variety	Days to Head	Plant Height	Plant Lodge	Test Weight	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	*	inches	0-9**	lbs/bu	------------ Bushels per acre ------------				
Newburg	70	50	5	32.0	122.9	126.2	172.5	149.3	140.5
CDC Minstrel	76	42	0	33.0	112.1	140.4	167.9	154.1	140.1
Furlong	75	44	2	30.2	122.7	131.1	162.2	146.7	138.7
Jury	69	48	5	34.1	116.1	135.3	163.1	149.2	138.2
Stallion	70	47	7	36.4	120.6	139.0	150.8	144.9	136.8
Killdeer	70	41	4	34.0	113.7	131.0	164.0	147.5	136.2
Shelby 427	65	43	2	36.5	127.5	127.1	145.9	136.5	133.5
AC Pinnacle	76	44	2	32.9	117.5	133.0	148.8	140.9	133.1
Rockford	74	48	2	35.6	113.5	126.9	156.1	141.5	132.2
Beach	75	47	1	35.1	113.9	120.3	152.2	136.3	128.8
Morton	72	47	1	31.9	112.1	115.5	156.8	136.1	128.1
Leggett	76	45	2	33.5	95.4	124.6	162.4	143.5	127.5
Otana	73	47	3	33.7	67.2	141.6	167.6	154.6	125.5
Souris	74	40	2	32.7	113.5	118.3	136.7	127.5	122.8
HiFi	75	45	2	32.6	103.8	111.5	135.6	123.5	117.0
CDC Dancer	76	47	0	33.7	67.7	118.9	151.5	135.2	112.7
Stark	74	46	4	35.4	90.9	94.8	138.2	116.5	108.0
Hytest	71	47	5	36.7	70.2	120.5	130.2	125.3	107.0
Horsepower	67	39	2	35.2	--	132.9	159.5	146.2	--
Goliath	73	53	5	36.1	--	--	161.0	--	--
Trial Mean	72	46	3	34.5	104.1	124.3	157.0	--	--
C.V. %	1.7	3.0	38.7	2.9	4.1	3.8	5.0	--	--
LSD 10%	1	2	1	1.2	4.6	5.6	9.3	--	--

* Days to Head = the number of days from planting to head emergence from the boot.
** 0 = no lodging, 9 = 100% lodged.
Planting Date: April 25
Harvest Date: August 14
Seeding Rate: 750,000 live seeds / acre.
Previous Crop: Canola

Safflower Variety Descriptions

Variety	Origin [1]	PVP [6]	Hull Type [2]	Oil Type [3]	Irrigated Yield [4]	Dryland Yield [4]	TWT [4]	Oil [3]	Maturity	Tolerance [5] Alt.	Tolerance [5] BB
Cardinal	MT/ND	yes	N	high lino	v good	v good	high	fair	med	T	MT
Centennial	MT/ND	yes	STP	linoleic	m good	good	med	v good	m late	MT	MT
Finch	MT/ND	no	N	linoeic	good	v good	v high	fair	m early	MS	T
MonDak	MT/ND	yes	N	high oleic	good	v good	high	fair	m early	T	MT
Morlin	MT/ND	yes	STP	high linoleic	v good	good	med	good	m late	T	T
Nutrasaff	MT/ND	yes	RED	linoeic	good	good	med	high	med	T	MT
S-541	ST	no	STP	linoeic	fair	v good	m high	v good	m late	MS	MS
Montola 2000	MT/ND	yes	N	high oleic	m good	good	med	good	early	MS	MS
Montola 2001	MT/ND	yes	STP	high oleic	good	fair	med	good	med	MT	MT
Montola 2003	MT/ND	yes	N	high oleic	v good	v good	m high	good	m early	MT	MT
Montola 2004	MT/ND	yes	N	high oleic	good	good	m high	good	m early	MS	MT

[1] ST -= SeedTec International, MT = Montana, ND = North Dakota
[2] STP = striped, N = normal, RED = reduced
[3] Lino - linoleic
[4] Relative ratings of yield, test weight, and oil will vary under conditions of moderate-severe disease infestation
[5] Alt = Alternaria leaf spot disease, BB = bacterial blight, S = susceptible, MS = moderately susceptible, MT = moderately tolerant, T = tolerant
[6] "yes" indicates the variety is protected and the seed may be sold for planting purposes only as a class of certified seed (Title V option)

Safflower - 2013 **Hettinger, ND**

Variety	Days to Flower	Plant Height	Test Weight	Grain Yield 2011	Grain Yield 2012	Grain Yield 2013	Average Yield 2-Yr	Average Yield 3-Yr
	DAP*	inches	lbs/bu	lbs per acre				
Cardinal	93	37	36.1	1607	2381	2394	2388	2127
Finch	90	34	37.8	1785	2073	2272	2173	2043
MonDak	92	32	35.2	2078	2358	2303	2331	2246
Montola 2003	92	30	34.6	2057	2060	2186	2123	2101
Morlin	92	30	33.9	--	--	1776	--	--
Nutrasaff	91	34	34.6	938	1366	2124	1745	1476
Hybrid 9049	89	32	36.1	2100	2601	2978	2790	2560
Hybrid 1601	90	33	33.0	1791	2993	2182	2588	2322
Trial Mean	91	32	35.2	1777	2272	2277	2305	2125
C.V. %	0.9	4.6	2.8	8.0	10.6	8.8	--	--
LSD 10%	2.0	1	1.2	140	320	244	--	--

* Days after planting.

Planting Date: April 26

Harvest Date: September 11

Seeding Rate: 300,000 live seeds / acre.

Previous Crop: No-till Green Fallow Spring Wheat

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Canola - Clearfield - 2013 **Hettinger, ND**

Brand	Variety	Oil Type	Days to Bloom	Bloom Duration	Days to Mature	Plant Height	Lodging	Test Weight	Oil Content	Seed Yield 2013	Seed Yield 2-Yr. Avg.
		*	**	days	**	inches	0 - 9***	lbs/bu	%	-------lbs/a-------	
Croplan	VT X 121 CL	TR	43	25	90	33	3	51.8	42.1	757	--
Mycogen	Nexera 2012 CL	HO	47	23	92	32	1	50.5	44.4	621	672
Mycogen	CL268726H	HO	49	22	91	34	0	51.1	45.9	1056	--
Mycogen	CL2537357H	HO	49	22	92	36	0	50.8	45.3	1126	--
Trial Mean			47	23	91	34	1	51.0	44.4	890	--
C.V. %			0.6	2.3	0.8	2.3	51.0	1.7	1.9	14.5	--
LSD 10%			0.4	0.7	1.0	3.2	0.6	1.1	1.1	167	--

* Type: TR-Traditional Oil Type, HO-High Oleic Oil Type.
** Days after planting.
*** Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: May 7
Harvest Date: August 17
Previous Crop: No-till Green Fallow Spring Wheat

Canola - Roundup Ready - 2013 **Hettinger, ND**

Brand	Variety	Oil Type	Days to Bloom	Bloom Duration	Days to Mature	Plant Height	Lodging	Test Weight	Oil Content	Seed Yield 2013	Seed Yield 2Yr Avg
		*	**	days	**	inches	0 - 9***	lbs/bu	%	-------lbs/a-------	
Cargill	V12-1	HO	50	22	91	39	1	50.8	43.9	1718	1419
Cargill	V12-2	HO	50	22	92	38	0	50.6	44.0	1533	--
Cargill	v2045	HO	48	22	91	37	0	50.9	44.2	1411	1238
Cargill	v2170	TR	50	23	92	36	0	50.8	44.2	1566	1246
Croplan	930	TR	47	23	90	41	0	52.9	45.3	1647	--
Croplan	955	TR	48	22	89	41	1	52.4	45.3	2054	1536
Croplan	969	TR	47	22	89	40	1	52.6	44.8	2008	--
BrettYoung	6070 RR	TR	48	23	93	40	0	52.0	43.2	1539	1325
BrettYoung	6040 RR	TR	48	23	92	41	0	53.0	42.5	1696	--
Mycogen Seeds	Nexera 1012 RR	HO	50	26	98	42	0	51.0	44.0	1593	1204
Mycogen Seeds	Nexera 1016 RR	HO	48	23	92	40	1	52.0	42.2	1301	1068
Mycogen Seeds	G1570046H	HO	50	24	95	40	0	50.6	41.5	1482	--
Mycogen Seeds	G1570048H	HO	51	22	94	37	0	49.6	42.1	1119	--
Proseed	CS 1	TR	47	23	90	38	2	52.9	44.7	1650	--
Proseed	CD 2	TR	47	22	89	37	1	52.7	45.0	1570	--
Star Specialty Seed	Star 402	TR	48	22	90	38	0	52.6	46.8	1700	1293
Star Specialty Seed	Star 514	TR	46	23	90	37	3	53.1	44.5	1460	--
DeKalb	DKL30-42	TR	47	24	93	36	2	52.2	42.7	1422	--
DeKalb	DKL38-48	TR	47	23	91	36	1	52.9	43.9	1727	--
DeKalb	DKL55-55	TR	47	24	92	34	2	52.5	45.5	1370	--
DeKalb	DKL70-07	TR	48	25	95	35	1	51.8	44.5	1770	--
DeKalb	DKL72-40	TR	48	23	92	36	0	52.0	46.3	1639	--
Trial Mean			48	23	92	38	1	51.8	44.3	1607	--
C.V. %			1.2	3.3	3.3	7.3	142	1.3	1.8	12.6	--
LSD 10%			1	1	1	3	1	0.8	1.0	240	--

* Type: TR-Traditional Oil Type, HO-High Oleic Oil Type.

** Days after planting.

*** Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: May 7

Harvest Date: August 17

Previous Crop: No-till Green Fallow Spring Wheat

NDSU Hettinger Research Extension Center

Chickpea - 2013 **Hettinger, ND**

Variety	Days to Flower	Height	Lodging	1,000 Seed Wt.	Seeds Lb	Test Weight	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	DAP*	inches	0 - 9**	gm	seeds	lb/bu	---lb/a---				
Kabuli Type											
CDC Alma	60	14	0	479	953	55.9	--	--	2131	--	--
CDC Frontier	60	17	0	426	1066	56.0	1106	2855	2380	2618	2114
CDC Luna	59	15	0	434	1049	53.7	1114	3134	1976	2555	2075
CDC Orion	58	16	0	489	931	53.4	--	--	2202	--	--
Dylan	59	16	0	410	1112	55.3	145	1445	1214	1330	935
Sawyer	59	18	0	491	924	54.1	1090	2242	1781	2012	1704
Sierra	60	18	0	480	945	49.6	457	1457	610	1034	841
Small Kabuli Type											
B-90	63	17	0	253	1797	51.6	1029	2813	1914	2364	1919
Desi Type											
CDC Anna	60	18	0	217	2095	49.8	1692	2651	2281	2466	2208
Mean	60	17	0	433	1130	54.0	777	2227	1924	--	--
C.V. %	0.6	9.0	0.0	4.5	5.2	2.6	35.0	6.6	11.4	--	--
LSD 10%	1	2	0	23	70	1.7	98	180	262	--	--

* Days after planting.

** Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: April 26

Harvest Date: September 6

Previous Crop: No-till Green Fallow Spring Wheat

Clearfield Lentil - 2013 **Hettinger, ND**

Variety	Days to Flower	Flower Duration	Height	Lodging	Seed Protein	1,000 Seed Wt.	Seeds Lb	Test Weight	----- Grain Yield ----- 2011	2012	2013	Average Yield 2 yr	3 yr
	DAP*	days	inches	0 - 9**	%	gm	seeds	lb/bu	lb/a				
Large Green Type													
CDC Imigreen	56	20	16	3	23.8	61	7394	64.1	--	1212	2640	1926	--
Medium Green Type													
CDC Impress	55	21	14	6	20.7	52	8792	62.7	1760	1795	3260	2528	2272
Small Red Type													
CDC Maxim	55	21	13	3	23.0	39	11702	63.5	1874	2039	3132	2586	2348
Extra Small Red Type													
CDC Impala	56	20	15	3	23.9	28	15975	65.2	1712	1807	3086	2447	2202
Mean	55	21	14	4	23	45	10966	63.9	1755	1663	3029	--	--
C.V. %	0.8	1.6	8.6	20.2	1.5	2.4	2.5	0.5	4.6	5.5	8.2	--	--
LSD 10%	1	1	1	2	0.5	1	355	0.4	77	112	322	--	--

* Days after planting.

** Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: April 26

Harvest Date: August 15

Previous Crop: No-till Green Fallow Spring Wheat

NDSU Hettinger Reserach Extension Center

Lentil - 2013 | **Hettinger, ND**

Variety	Days to Flower	Flower Duration	Height	Lodging	Seed Protein	1,000 Seed Wt.	Seeds Lb	Test Weight	Grain Yield 2011	Grain Yield 2012	Grain Yield 2013	Average Yield 2 yr	Average Yield 3 yr
	DAP*	days	inches	0 - 9**	%	gm	seeds	lb/bu	lb/a				
Large Green Type													
CDC Greenland	63	21	12	4	22.4	63	7262	62.2	1551	1928	1789	1859	1756
Pennell	62	23	11	6	22.9	69	6623	62.2	1254	1698	1457	1578	1470
Riveland	63	19	12	6	22.5	68	6634	63.1	1010	1388	1580	1484	1326
Medium Green Type													
CDC Richlea	63	20	12	6	21.2	51	8855	63.6	1463	1986	1890	1938	1780
Avondale	63	21	12	5	21.7	49	9278	64.1	--	--	2171	--	--
Small Green Type													
CDC Viceroy	63	19	13	4	24.6	33	13685	63.5	1710	1962	3046	2504	2239
Essex	63	20	11	6	22.2	45	10042	65.1	1252	1875	2171	2023	1766
Eston	63	21	11	4	23.8	36	12678	64.5	--	--	2273	--	--
Small French Green Type													
CDC Lemay	62	21	10	6	22.3	34	13425	63.1	1140	1689	2393	2041	1741
Medium Red Type												--	--
CDC Red Rider	63	21	14	3	22	46	9826	62.0	--	--	3133	--	--
Small Red Type													
CDC Redberry	62	21	12	2	23	41	10990	63.3	1870	1876	2919	2398	2222
CDC Rouleau	63	19	11	6	20.8	37	12278	62.4	1656	1776	1926	1851	1786
Extra Small Red Type													
CDC Rosetown	62	22	12	2	23	32	14121	64.6	1711	2130	2942	2536	2261
Spanish Brown Type													
Morena	63	20	12	5	23	39	11579	64.6	1260	2094	2478	2286	1944
Mean	63	20	11	5	23	47	10297	63.4	1484	1932	2283	--	--
C.V. %	0.7	2.6	8.4	20.6	2.0	5.4	5.8	1.4	6.9	5.8	12.3	--	--
LSD 10%	1	1	1	1	0.6	3	707	1.1	111	133	332	--	--

* Days after planting.

** Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: April 26

Harvest Date: August 15

Previous Crop: No-till Green Fallow Spring Wheat

Field Pea - 2013 — **Hettinger, ND**

Variety	Days to Flower	Flower Duration	Days to Mature	Vine Length	Canopy Height	Height Index[1]	Lodging	Seed Protein	1,000 Seed Wt.	Seeds Lb	Test Weight	Seed Yield 2013	Seed Yield 2-Yr Avg	Seed Yield 3-Yr Avg
	DAP[2]	days	DAP[2]	inches	inches	%	0 - 9[3]	%	gm	seeds	lb/bu	bu/a	bu/a	bu/a
Yellow Cotyledon Type														
Agassiz	57	23	94	29	21	72	4	27.4	247	1837	63.6	52.6	48.7	52.0
Bridger	56	20	90	24	20	85	3	26.5	237	1917	63.1	53.0	52.6	--
CDC Meadow	56	22	92	25	17	69	5	25	216	2104	63.4	50.5	--	--
DS Admiral	56	17	88	25	17	67	6	25.4	223	2041	62.3	54.0	51.4	54.2
Gunner	57	21	92	25	18	72	5	26.1	225	2016	62.5	47.8	47.9	51.9
Korando	55	22	91	24	14	58	6	27.2	277	1644	62.5	49.2	51.1	55.5
Navarro	54	21	89	24	16	69	5	26.8	247	1861	62.9	49.2	--	--
Nette	55	17	86	23	18	81	5	24.9	225	2022	63.6	48.5	--	--
SW Midas	58	19	91	23	14	59	6	25.4	209	2167	63.7	51.0	50.0	52.8
Vegas	57	18	89	24	20	83	2	28.3	237	1921	64.7	41.9	44.7	49.6
Green Cotyledon Type														
CDC Striker	55	18	87	22	11	47	8	25.1	219	2075	62.7	52.6	51.2	49.8
Cruiser	57	21	92	23	14	63	6	26.6	207	2206	61.7	44.9	44.9	44.6
K2	56	22	91	20	18	90	3	25.6	215	2115	62.7	39.8	42.3	46.7
Majoret	56	19	89	24	14	56	7	27.7	221	2053	62.9	50.9	46.1	46.2
SW Arcadia	55	18	87	22	9	42	9	25.2	224	2058	62.2	54.3	53.2	52.6
Mean	57	19	90	24	17	69	5	26.4	237	1937	63.2	49.1	48.7	50.5
C.V. %	0.8	7.0	1.3	7.2	11.3	13.8	21.9	1.8	6.0	5.9	1.4	7.6	--	--
LSD 10%	1	2	1	2	2	11	1	0.6	17	135	1.0	4.4	--	--

[1] Harvest Index; Plant height at time of harvest relative to plant height at end of bloom.

[2] Days after planting.

[3] Lodging: 0 = none, 9 = lying flat on ground.

Planting Date: April 30

Harvest Date: August 8

Previous Crop: No-till Green Fallow Spring Wheat

Soybean - Conventional - 2013										**Hettinger, ND**
	Maturity	Plant	Test	Oil	Protein	----------Grain Yield-----------			Average Yield	
Variety		Height	Weight	Content	Content	2011	2012	2013	2-Yr	3-Yr
		inches	lbs/bu	%	%	----------------- Bushels per acre -----------------				
Traill	00.0	30	57.6	16.1	36.8	37.8	22.6	44.4	33.5	34.9
Cavalier	00.9	27	55.8	16.3	35.5	37.5	30.5	42.6	36.6	36.9
Ashtbula	0.4	34	55.4	15.9	39.1	37.8	33.6	46.1	39.9	39.2
Sheyenne	0.7	33	55.6	16.3	36.0	43.9	38.5	47.1	42.8	43.2
ProSoy	0.8	35	55.9	16.3	35.4	34.3	34.4	38.3	36.4	35.7
ND1005T	0.5	30	56.4	14.6	39.5	35.8	30.1	43.1	36.6	36.3
ND06-4642	0.5	28	56.3	15.9	35.6	--	--	47.2	--	--
Trial Mean	--	31	56.2	15.9	36.8	37.7	31.6	44.1	37.6	37.7
C.V. %	--	3.9	0.9	2.4	1.8	3.4	4.9	5.9	--	--
LSD 10%	--	1	0.6	0.5	0.8	1.8	1.9	1.7	--	--

Planting Date: May 15
Harvest Date: September 17
Previous Crop: No-till Green Fallow Spring Wheat

Soybean - Roundup Ready - 2013 — Hettinger, ND

Company	Variety	Maturity	Plant Height	Test Weight	Oil Content	Protein Content	Grain Yield 2011	Grain Yield 2013	Average 2-Yr
			inches	lbs/bu	%	%	Bushels per acre		
Proseed	PX 02	0.2	31	54.9	15.4	38.1	43.5	49.0	46.3
Proseed	PX 06	0.6	28	56.3	15.4	36.6	38.9	43.3	41.1
Integra Fortified Seed	20090 - GENRR2Y	00.9	29	55.4	16.4	34.1	--	46.1	--
Integra Fortified Seed	20300 - GENRR2Y	0.3	30	55.6	15.0	37.9	--	40.5	--
Integra Fortified Seed	20600 - GENRR2Y	0.6	31	55.8	15.2	36.9	--	43.1	--
Integra Fortified Seed	20902 - GENRR2Y	0.9	31	55.7	15.0	38.0	--	39.6	--
Trial Mean		--	30	55.6	15.4	36.9		43.6	43.7
C.V. %		--	4.9	0.9	1.9	0.8		6.2	--
LSD 10%		--	2	0.6	0.4	0.3		3.3	--

Planting Date: May 15
Harvest Date: September 22
Previous Crop: No-till Green Fallow Spring Wheat

NDSU Hettinger Research Extension Center

Dry Bean **Hettinger, ND**

Variety	Type	Days to Flowering	Plant Height	Plant Lodge	100 Seed Weight	Test Weight	Grain Yield 2010	Grain Yield 2011	Grain Yield 2013	Average Yield 2 yr	Average Yield 3 yr
		DAP*	inches	0-9**	grams	lbs/bu	lbs per acre				
LaPaz	Pinto	58	21	3	29.7	60.4	1995	1916	2779	2348	2230
Lariat	Pinto	55	21	5	32.9	57.1	2122	2068	2571	2320	2254
Mariah	Pinto	53	18	4	32.0	57.2	--	--	2780	--	--
Maverick	Pinto	53	18	4	33.0	56.5	1987	1791	2152	1972	1977
Medicine Hat	Pinto	53	19	4	34.1	54.7	2066	1532	2409	1971	2002
ND-307	Pinto	55	19	4	34.0	55.4	--	2184	2813	2499	--
Stampede	Pinto	55	19	4	31.3	55.2	1559	1914	2552	2233	2008
Windbreaker	Pinto	54	19	3	35.9	55.1	1942	1645	2216	1931	1934
Avalanche	Navy	55	20	3	19.6	58.9	1556	1549	2571	2060	1892
Ensign	Navy	55	20	4	18.1	58.3	1380	1401	2780	2091	1854
HMS Medalist	Navy	55	21	1	16.3	59.6	1447	1253	2562	1908	1754
Norstar	Navy	56	19	5	16.5	61.2	--	--	1653	--	--
Navigator	Navy	54	22	1	15.4	59.5	--	--	2505	--	--
Vista	Navy	57	22	3	15.1	59.4	1611	1370	1994	1682	1658
T9905	Navy	57	20	3	17.4	59.9	--	--	3082	--	--
Merlot	Sm Red	56	20	5	32.1	58.1	1589	1496	1961	1729	1682
Rio Rojo	Sm Red	55	21	4	25.6	62.5	--	--	2548	--	--
Sedona	Pink	59	21	5	29.9	54.1	838	612	1533	1073	994
Eclipse	Black	57	20	1	15.5	57.0	1784	1707	2246	1977	1912
Loreto	Black	59	21	2	16.2	59.5	1227	1502	2190	1846	1640
Zorro	Black	57	22	1	16.3	57.0	2043	1573	2155	1864	1924
Trial Mean		57	20	3	24.9	57.8	1640	1656	2402	--	--
C.V. %		--	8.0	19.8	4.5	1.9	6.1	7.5	7.7	--	--
LSD 10%		--	2	1	1.3	1.3	165.0	177.0	217.0	--	--

* Days after planting.

** 0 = no lodging, 9 = lying flat on ground.

Planting Date: May 22

Harvest Date: September 13

Seeding Rate: 100,000 live seeds / acre.

Previous Crop: Spring Wheat Green Fallow

NDSU Hettinger Research Extension Center

Oil Type Sunflower - 2013 **Hettinger, ND**

Brand	Variety	Oil Type & Traits	Days to Bloom	Plant Height	Lodging	Test Weight	Oil Content	Yield 2013
		*	**	inches	%	lbs/bu	%	lbs/ac
AgVenture	3H93CL/DM	HO, CL, DM	75	73	13	27.4	34.1	1417
AgVenture	3H94CL/DM	NS, CL, DM	78	77	3	27.9	34.3	2593
AgVenture	3H95CL	HO, CL, DM	77	74	6	26.8	33.7	1486
Croplan	432 E	NS, EX, DM	74	75	12	28.0	32.5	1979
Croplan	460 E	NS, EX	79	79	11	26.3	34.6	1783
Croplan	559 CL	NS, CL, DM	79	83	8	27.0	35.1	1773
Croplan	548 CL	NS, CL, DM	78	82	6	28.8	34.5	2057
Croplan	13-59 CL	NS, CL, DM	80	78	7	26.0	33.0	2407
Genosys	11G08	NS	80	82	10	28.0	34.6	1966
Genosys	12G20	HO, CL	76	74	14	27.4	34.6	2153
Genosys	12E06	HO, DM	75	86	10	28.3	33.3	2101
Genosys	12E12	HO, CL, DM	77	87	3	26.6	33.0	1868
Genosys	12E13	HO, CL, DM	77	80	4	25.4	32.4	1635
Genosys	12E14	HO, CL, DM	80	88	6	24.7	32.1	1924
Mycogen Seeds	8N358CLDM	NS, CL, DM	76	79	10	28.8	37.1	1310
Mycogen Seeds	8N421CLDM	NS, CL, DM	78	77	5	27.3	34.0	1807
Mycogen Seeds	8H449CLDM	NS, CL, DM	78	72	24	31.2	38.6	1928
Mycogen Seeds	8D310CL	NS, CL	80	83	19	24.3	32.4	1636
Mycogen Seeds	8N270CLDM	NS, CL, DM	74	74	30	27.4	35.0	828
Seeds 2000	Falcon	NS, EX	77	73	3	28.5	33.4	2392
Seeds 2000	Durango	NS, EX	81	71	7	27.8	34.5	1885
Seeds 2000	Camaro II	NS, CL, DM	78	79	8	27.7	33.5	2047
Seeds 2000	Torino	NS, CL	81	74	5	28.6	34.3	2147
Seeds 2000	Cobalt II	HO, CL, DM	76	73	12	28.1	34.1	1614
Seeds 2000	Daytona	HO, CL	78	75	3	27.3	34.4	1655
Seeds 2000	NLK12S069	NS, EX	77	75	14	24.7	32.4	1539
Seeds 2000	NLK12S070	NS, EX	75	70	15	26.3	34.9	1626
Seeds 2000	Hornet	HO, CL, DM	80	80	18	26.8	33.4	2399
Syngenta	3845 HO	HO	77	78	14	26.3	34.8	1906
Syngenta	7111 HO/CL/DM	HO, CL, DM	74	72	24	27.9	34.2	1438
Syngenta	3733 NS/DM	NS, DM	80	75	40	26.2	35.7	1098
Proseed	E-21 CL	HO, CL	77	82	10	26.5	33.0	1646
Proseed	E-85 CL	HO, CL	78	85	10	25.4	33.7	1646
Proseed	E-31 CL	HO, CL	79	83	6	25.8	32.5	1908
Proseed	E-362436	HO	75	88	13	28.7	33.2	1946
Trial Mean			77	78	11	27.1	34.0	1816
C.V. %			1.5	3.7	88.8	2.4	4.2	15.6
LSD 10%			1	3	12	0.8	1.7	345

* Type: NS-NuSun, HO-High Oleic, CL=Clearfield, EX=ExpressSun, DM=Downy Mildew Resistant

** Days after planting.

Planting Date: May 15

Harvest Date: October 26

Previous Crop: Wheat

NDSU Hettinger Research Extension Center

Corn - 2013 **Hettinger, ND**

Company	Hybrid	Traits*	Relavtive Maturity*	Plant Height	Ear Height	Stalk Lodge	Moisture Content	Test Weight	Yield 2013
			days	inches	inches	%	%	lbs/bu	bu/ac
Proseed	PX85R	VT2P	85	104	44	0	22.8	55.9	147
Proseed	PX85B	VT2P	85	100	39	0	20.2	57.2	109
Proseed	1283	VT2P	83	94	40	0	18.4	56.2	135
Proseed	PX82M	GTCBLL	82	100	41	2	19.7	53.8	124
Proseed	1083	VIPGTCBLL	83	97	42	1	18.5	53.8	163
Integra	9352	VT2PRO	85	102	44	0	25.1	56.8	155
Integra	3537	VT2PRO	85	102	45	0	22.5	55.8	151
Integra	3314-3110	GT	83	92	40	0	21.8	54.5	134
Integra	9333	VT2PRO	83	102	47	0	21.4	57.8	130
AgVenture	R2774	RR	84	96	45	1	20.1	52.2	134
AgVenture	GL2949AB	RR/BT	84	99	42	0	20.7	55.4	145
AgVenture	GL2708AB	RR/BT	87	102	43	3	25.5	55.5	126
AgVenture	GL4132ABW	RR/BT/RW	89	100	46	0	27.4	55.9	135
AgVenture	R4492	RR	91	99	43	0	21.0	55.8	147
Trial Mean			--	99	43	1	21.8	55.5	138
C.V. %			--	4.5	7.4	143.2	8.9	1.2	11.8
LSD 10%			--	5	4	1	2.3	0.8	19

* Traits and relavtive maturity provided by the company.

Planting Date: May 15

Harvest Date: October 26

Previous Crop: Wheat

Grain Sorghum - 2013 **Hettinger, ND**

Company	Hybrid	50% Bloom Date	50% Bloom DAP*	Plant Height	Lodging	Moisture Content	Test Weight	Yield 2013
			days	inches	%	%	lbs/bu	bu/ac
Sorghum Partners	251	8/18	73	43	59	20.0	52.7	25
Sorghum Partners	SP3303	8/26	81	43	26	16.4	45.9	40
Sorghum Partners	K35-Y5	8/25	80	43	73	16.5	42.2	41
Sorghum Partners	KS310	8/24	79	45	56	17.0	39.1	31
Sorghum Partners	SP3425	8/26	81	39	55	21.2	44.9	31
DeKalb	DKS26-60	8/20	75	42	65	16.1	45.0	54
DeKalb	DKS28-05	8/20	75	48	48	18.3	43.6	40
DeKalb	DKS29-28	8/23	78	41	63	17.6	44.9	40
Monsanto	MSK180	8/27	82	47	55	22.7	39.7	38
Monsanto	MSK181	8/27	82	47	19	23.9	39.0	34
Mycogen	1G557	8/22	77	44	49	17.2	43.3	46
Mycogen	1G600	9/3	89	46	41	24.4	33.2	19
Trial Mean		--	79	44	51	19.3	42.8	36
C.V. %		--	1.1	3.5	34.7	9.7	4.2	28.0
LSD 10%		--	1	2	21	2.2	2.2	12

* Days after planing.

Planting Date: June 7

Harvest Date: October 27

Previous Crop: Durum wheat

The grain sorghum suffered from heavy lodging due to the blizzard on October 4-5.
Many of the hybrids were not mature at that time which led to poor test weights and yields.

Bayer Broadleaf Weed Control in HRSW

John Rickertsen, Hettinger, ND

Trt. No.	Treatment Description	Rate	Rate Unit	20-Jun bindw	20-Jun wibw	3-Jul bindw	3-Jul wibw	15-Aug bindw	15-Aug wibw	15-Aug jabr	22-Aug TWT	22-Aug Yield
				----% control----		----% control----		----------% control----------			lb/bu	bu/ac
1	UNTREATED			0	0	0	0	0	0	0	60.5	25.7
2	HUSKIE	11	OZ/A	90	99	25	99	10	99	10	61.8	29.3
	AMS	0.5	LB WT/A									
3	HUSKIE	13.5	OZ/A	95	99	13	99	5	99	3	61.1	31.6
	AMS	0.5	LB WT/A									
4	HUSKIE COMPLETE	13.7	OZ/A	95	99	68	99	30	99	90	61.9	39.5
	AMS	0.5	LB WT/A									
5	VARRO	6.85	OZ/A	95	99	83	99	78	99	88	62.3	35.1
	Bison Advanced	0.8	PT/A									
6	WideMatch	16	OZ/A	48	85	83	99	65	99	8	63.3	29.2
	MCPA	8	OZ/A									
7	Affinity TankMix	0.6	OZ WT/A	85	99	80	99	35	99	0	61.9	30.5
	Starane Ultra	4.32	OZ/A									
	NIS	0.25	% V/V									
	Mean			73	83	50	85	32	85	28	61.8	31.6
	LSD (.05)			6	3	6	1	34	1	8	1.7	8.1
	CV			5.5	2.6	7.9	0	80.8	0	19.2	1.8	17.3

Planting Date: 5/6/13
Harvest Date: 8/22/13
Variety: Select HRSW

Application Date: 6/12/13
Application Time: 8:45-9:00 PM
Air Temp: 64
Relative Humidity: 68%
Wind Speed / Dir: 0-5 SSE
% Clouds: 30%
Crop Stage: 4-5 leaf

bindw = field bindweed
wibw = wild buckwheat
jabr = japanese brome

Summary

No crop injury was observed. All herbicide treatments provided excellent control of wild buckwheat. Huskie, Huskie Complete, Varro and Affinity showed good early season control of bindweed but only Widematch and Varro had some season long control. The other herbicide treatments were limited in season long control of bindweed. This trial had a significant japanese brome infestation and only Huskie Complete and Varro had some control of it. The lack of control of japanese brome in the other treatments was a major factor in their reduced yields compared to treatments 4 and 5.

Bayer Spring Burndown and Japanese Brome Control on HRSW

Trt. No.	Treatment Description	Rate	Rate Unit	Appl. Time	14-Jun VCRR	14-Jun jabr	27-Jun jabr	15-Aug jabr	22-Aug TWT	22-Aug Yield
						----------% control-----------			lb/bu	bu/A
1	ROUNDUP WEATHERMAX	16	OZ/A	PP	0	53	73	53	58.9	31.7
	AMS	17	LB/100 GAL	PP						
	HUSKIE	11	OZ/A	POST						
	AMS	0.5	LB/A	POST						
2	ROUNDUP WEATHERMAX	16	OZ/A	PP	1	85	95	99	61.4	51.8
	AMS	17	LB/100 GAL	PP						
	HUSKIE COMPLETE	13.7	OZ/A	POST						
3	ROUNDUP WEATHERMAX	16	OZ/A	PP	1	90	91	97	60.1	46.2
	AMS	17	LB/100 GAL	PP						
	HUSKIE COMPLETE	13.7	OZ/A	POST						
	AMS	0.5	LB/A	POST						
4	ROUNDUP WEATHERMAX	16	OZ/A	PP	1	90	98	99	63.0	51.4
	AMS	17	LB/100 GAL	PP						
	HUSKIE COMPLETE	13.7	OZ/A	POST						
	OLYMPUS	0.2	OZ/A	POST						
	AMS	17	LB/100 GAL	POST						
5	ROUNDUP WEATHERMAX	16	OZ/A	PP	0	85	96	99	58.4	38.8
	OLYMPUS	0.2	OZ/A	PP						
	AMS	17	LB/100 GAL	PP						
	HUSKIE COMPLETE	13.7	OZ/A	POST						
	AMS	0.5	LB/A	POST						
6	ROUNDUP WEATHERMAX	16	OZ/A	PP	0	93	98	99	57.5	47.4
	OLYMPUS	0.2	OZ/A	PP						
	AMS	17	LB/100 GAL	PP						
	HUSKIE COMPLETE	13.7	OZ/A	POST						
	OLYMPUS	0.2	OZ/A	POST						
	AMS	0.5	LB/A	POST						
7	ROUNDUP WEATHERMAX	16	OZ/A	PP	0	88	97	99	60.1	43.8
	AMS	17	LB/100 GAL	PP						
	RIMFIRE MAX	3	OZ/A	POST						
	HUSKIE	11	OZ/A	POST						
	MSO	20.8	OZ/A	POST						
8	ROUNDUP WEATHERMAX	16	OZ/A	PP	1	88	97	94	59.1	40.9
	OLYMPUS	0.2	OZ/A	PP						
	AMS	17	LB/100 GAL	PP						
	RIMFIRE MAX	3	OZ/A	POST						
	HUSKIE	11	OZ/A	POST						
	MSO	20.8	OZ/A	POST						
9	ROUNDUP WEATHERMAX	16	OZ/A	PP	3	84	97	99	60.6	43.4
	AMS	17	LB/100 GAL	PP						
	Everest 2.0	1	OZ/A	POST						
	HUSKIE	11	OZ/A	POST						
	NIS	0.25	% V/V	POST						
10	ROUNDUP WEATHERMAX	16	OZ/A	PP	1	89	86	97	58.8	34.8
	PRE-PARE	0.3	OZ/A	PP						
	AMS	17	LB/100 GAL	PP						
	Everest 2.0	0.5	OZ/A	POST						
	HUSKIE	11	OZ/A	POST						
	NIS	0.25	% V/V	POST						
	Mean				1	84	93	93	59.8	43.0
	LSD (.05)				2	10	16	16	3.0	9.3
	CV				165.9	8.4	11.5	4.3	3.5	14.9

jabr = japanese brome

Bayer Grass Control in HRSW
John Rickertsen, Hettinger, ND

Trt. No.	Treatment Description	Rate	Rate Unit	20-Jun VCRR	20-Jun wiot	20-Jun jabr	3-Jul wiot	3-Jul jabr	15-Aug wiot	15-Aug jabr	22-Aug TWT	22-Aug Yield
					----% control----		----% control----		----% control----		lb/bu	bu/A
1	UNTREATED			0	0	0	0	0	0	0	60.9	32.6
2	RIMFIRE MAX	3	OZ WT/A	3	91	94	91	97	93	98	61.6	43.2
	HUSKIE	11	OZ/A									
	BASIC BLEND	1	% V/V									
3	RIMFIRE MAX	3	OZ WT/A	0	92	95	96	99	99	99	61.4	41.5
	HUSKIE	11	OZ/A									
	HSOC	12	OZ/A									
4	RIMFIRE MAX	3	OZ WT/A	0	92	93	93	99	99	99	62.6	42.3
	Affinity TankMix	0.6	OZ/A									
	Starane	5.28	OZ/A									
	BASIC BLEND	1	% V/V									
5	VARRO	6.85	OZ/A	0	91	95	88	99	99	99	62.9	44.0
	Bison Advanced	12.8	OZ/A									
6	HUSKIE COMPLETE	13.7	OZ/A	0	90	95	91	99	99	99	61.6	38.5
	AMS	0.5	LB WT/A									
7	WOLVERINE	27.4	OZ/A	0	25	94	28	97	58	96	60.5	30.4
	Mean			0	69	81	69	84	78	84	61.6	38.9
	LSD (.05)			2	2	3	6	3	2	2	1.4	7.2
	CV			305.0	5.6	2.3	5.6	2.2	10.3	2.0	17.1	12.5

Planting Date: 5/6/13
Harvest Date: 8/22/13
Variety: Select HRSW

Application Date: 6/12/13
Application Time: 8:30-8:45 PM
Air Temp: 64
Relative Humidity: 68%
Wind Speed / Dir: 0-5 SSE
% Clouds: 30%
Crop Stage: 4-5 leaf

wiot = wild oat
jabr = japanese brome

Summary

Very little to no crop injury was observed. All herbicide treatments provided good control of japanese brome and all the herbicide treatments with the exception of Wolverine (treatment 7) provided good control of wild oats.

Planting Date: 5/6/13
Harvest Date: 8/22/13
Variety: Select HRSW

	PP	POST
Application Date:	5/7/13	6/6/2013
Application Time:	4:30-5:00 PM	3:00-3:30 PM
Air Temp:	75	65
Relative Humidity:	18%	68%
Wind Speed / Dir:	5-8 SSE	3-5 SSE
% Clouds:	30	25
Crop Stage:	--	4 leaf

Summary

Very little crop injury was observed. The Roundup + Huskie treatment (treatment 1) provided good control of the emerged japanese brome, but no control of later emerging plants. All the other treatments provided good season long control of japanese brome.

Effects of artificial insemination and natural service breeding systems on steer progeny backgrounding performance

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The objective of this study was to determine the backgrounding performance of calves born early or late in the calving season and from breeding systems that incorporated artificial insemination (AI) or relied solely on natural service. Although distinct performance advantages of AI calves were not observed, calves born early in the calving season had greater feed intake and gain, compared with calves born later in the calving season.

Summary

One hundred eighty-four steers were born from dams exposed to one of two treatments: natural service (NS, cows were only exposed to herd bulls for the duration of the breeding season) and fixed-timed artificial insemination (TAI, cows exposed to estrous synchronization and fixed-time AI followed by natural-service bulls). Within the dams' treatment, steers were divided into two blocks: calves born from day 0 to 26 of the calving season (Early, n = 119) and calves born after day 26 of the calving season (Late, n = 65) and were placed in one of 24 pens for a 65-day backgrounding period. Diets consisted of 61.7 percent ground grass hay, 25.8 percent barley and 12.5 percent liquid supplement on a dry-matter (DM) basis and were delivered once daily. At the initiation of the study, early born calves in the TAI treatment (549 pounds) were heavier ($P < 0.05$), compared with early born calves from the NS treatment (514 pounds), which were heavier that late-born calves of either treatment (468 and 464 pounds for TAI and NS, respectively; treatment × block; $P = 0.001$). Steers in the NS treatment had greater ($P < 0.05$) average daily gain (ADG) than TAI steers, 2.9 and 2.6 pounds/day, respectively. Steers in the TAI treatment (0.16 gain:feed [G:F]) had lower ($P < 0.05$) G:F than NS steers (0.18 G:F). Early born steers had greater ($P < 0.05$) final body weight (BW), dry-matter intake (DMI) and ADG (727 pounds, 16.4 pounds/day and 2.87 pounds/day, respectively), compared with Late-born steers (648 pounds, 15 pounds/day and 2.62 pounds/day, respectively). In summary, calves in the AI treatment did not outperform their NS counterparts, and Early born steers had greater final BW, DMI and ADG than Late-born calves.

Introduction

Locally available forage and grain supplies give cattlemen in the upper Great Plains a competitive advantage in placing gain on calves after weaning, compared with regions that require feed to be purchased and hauled long distances. A recent survey revealed that in 2009 to 2011, approximately 42.9 percent of the North Dakota calf crop was retained by their respective owner through a backgrounding phase (Dahlen et al., 2013).

Artificial insemination (AI) can improve the genetic base of a herd rapidly, compared with most natural-service sires by utilizing bulls with superior genetics at costs well below the cost of using a herd bull with equivalent genetic potential. Sires with superior growth and feed efficiency genetics may produce offspring with improved performance in the post-weaning phase (Welch et al., 2012; Johnson and Jones, 2008). Selecting for optimal growth traits with high-accuracy expected progeny differences (EPDs) may optimize backgrounding performance after weaning. However, only 7.6 percent of all beef operations use AI (NAHMS 2009).

Calf age at weaning also can influence herd performance by shifting the calving or weaning date (Lusby et al., 1981). Our research leading up to the current study has highlighted the fact that incorporating AI into a management scheme can result in older calves and early born calves that are heavier at weaning, compared with a breeding system that relies solely on natural service (Steichen et al., 2013).

However, the post-weaning performance impacts of each respective breeding system are unknown. Therefore, the objective of this study was to evaluate the impact of incorporating AI or natural-service breeding systems and the impact of calf age on steer performance during a 65-day backgrounding period.

Experimental Procedures

All procedures were approved by the Institutional Animal Care and Use Committee at NDSU.

One hundred eighty-four Angus crossbred steer calves were used to evaluate the effects of dam breeding systems on backgrounding performance. Calves originating from the Central Grasslands Research Extension Center near Streeter, N.D., (n = 159; born in March-April) were shipped (235 miles) and joined steers originating from the Hettinger Research Extension Center (n = 25; born in April) at the Southwest Feeders feedlot in Hettinger, N.D., for a 65-day backgrounding trial. The trial began in early October and ran through mid-December.

Calves originated from dams that were assigned to one of two breeding systems (Steichen et al., 2012):

1) Natural-service bulls for the duration of the breeding season (NS)
2) Estrus synchronization and artificial insemination followed by exposure to natural-service bulls (AI).

Within the dams' treatment, steers were divided into two blocks: 1) calves born from day 0 to 26 of the calving season (Early n = 119) and 2) calves born after day 26 of the calving season (Late, n = 65). In the AI treatment, all calves that were born from AI sires (as opposed to cleanup bulls) were included in the Early block, whereas an equivalent number of natural-service calves were included in the Early block for the NS treatment, resulting in the day 26 cutoff. Steers were assigned randomly to one of 24 pens (six to nine head/pen; Early, n = 16; Late, n = 8).

At the initiation and end of the study, all steers received a Ralgro implant (36 milligrams of zeranol; Merck Animal Health, Summit, N.J.). Steer weights were determined on two consecutive days at the beginning and the end of the project prior to each morning's ration delivery.

All steers were fed a common total mixed ration once daily at 8 a.m. targeting ad libitum intake. The diet consisted of 61.7 percent ground grass hay, 25.8 percent barley and 12.5 percent liquid supplement (Quality Liquid Feeds, Dodgeville, Wis.) on a DM basis. The diet had added water (2 pounds per head/ day) to minimize dust from hay.

All steers had access to fresh water in their pens. The amount of feed delivered was monitored daily, and feed refusals were collected, weighed and sampled once weekly.

Results and Discussion

A treatment × block interaction ($P = 0.001$) occurred for initial BW (Table 1). Early born calves in the TAI treatment were heaviest ($P = 0.05$), followed by early born calves in the NS treatment, followed ($P = 0.05$) by late-born calves in the TAI and NS treatments, respectively. Final body weight also was influenced by a treatment × block interaction ($P = 0.052$).

At the end of the study, early born calves from the TAI treatment tended to be heavier ($P = 0.09$) than early born steers in the NS treatment, which were heavier ($P < 0.05$) than late-born calves in the TAI or NS treatments. Maintaining a weight advantage through the backgrounding phase may allow early born AI calves to be sold at a greater price per calf, compared with NS calves. However, we did not evaluate sales prices at the end of the backgrounding phase.

Natural-service steers had greater ($P < 0.05$) ADG and gain:feed ratios, as well as a lower feed cost of gain, compared with TAI steers. One rationale for the performance difference among treatments would be that the genetic potential of the herd bulls for gain was greater than that of the AI sires. Bulls in both treatments, however, were in the top 25 percent of the Angus breed for weaning weight and yearling weight EPDs.

Most likely, the lower start weight of calves in the NS treatment allowed for compensatory gain of NS during the feeding period (Lofgreen and Kiesling, 1985), which manifested itself in the form of greater gain and feed efficiency, compared with AI calves. Slight differences in age among early born calves in the AI and NS treatment also may have contributed to slight performance differences.

Early born steers had greater ($P < 0.05$) final BW, intake and average daily gain than Late-born steers. Because early born calves were heavier, the pattern of greater intake and gain was expected. Similarly, steers born early gained an additional 0.22 pound/day, compared with later-born calves (Smith et al., 2003). An additional report, however, showed no difference in gain among calves born during different calving periods (Funston et al., 2012).

No differences ($P > 0.10$) in feed efficiency were present among calving groups in the current study. This is in contrast to other reports of cattle during the finishing period (Fike et al., 2010). Perhaps the moderate-energy diets in the current study (as opposed to high-energy diets of previous finishing work) did not allow for differentiation of potential feed efficiency measures among early and late-calving groups.

The utilization of a breeding system that incorporates fixed-time artificial insemination yielded an advantage of having greater pre-backgrounding and post-backgrounding body weight. However, calves born in the AI treatment did not have advantages over NS calves in other performance measures (ADG and G:F). Overall, calves born early in the calving season grew faster, compared with those born later in the calving season.

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Table 1. Effects of treatment and calving season on steer backgrounding performance.

	Treatment[1]							
	TAI		NS			*P* - value		
Item	Early[2]	Late[2]	Early	Late	SE	Trt	Block	Interaction
Age, day	180	153	173	153	--	--	--	--
Initial BW, lb.	549.2[x]	467.7[z]	514.0[y]	463.9[z]	4.54	<0.001	<0.001	<0.001
Final BW, lb.	735.9[xa]	640.3[y]	721.6[xb]	655.0[y]	8.13	0.975	<0.001	0.052
DMI, lb./head/day	16.7	14.9	16.7	15.0	0.37	0.541	<0.001	0.389
ADG, lb./head/day	2.71	2.49	2.99	2.76	0.09	<0.001	0.007	0.828
G:F	0.16	0.17	0.19	0.18	0.01	<0.001	0.655	0.377
Cost of gain, $/lb[3]	0.73	0.71	0.64	0.64	0.02	<0.001	0.554	0.330

[1]Treatments were dams exposed to fixed-time AI (TAI) 7-day CO-Synch + CIDR with cleanup bull, or natural service (NS) bulls for the duration of the breeding season.
[2]Calves were blocked by calving date into Early (born in first 26 days) and late (born after day 26) blocks, respectively.
[3]Feed cost of gain with hay priced at $145/ton, barley at $5.75/bushel and supplement at $350/ton.
[x,y,z]Means within row lacking common superscript differ ($P < 0.01$).
[a,b]Means within row lacking common superscript tend to differ ($P < 0.10$)

Effects of dietary forage concentration in finishing diets on growth and carcass characteristics of steers

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The objective of this study was to evaluate the effect of feeding different levels of forage during the finishing phase of beef production. Three different finishing diets of 20, 30 and 40 percent forage were fed to feedlot yearling steers to assess effects on growth and meat quality traits. Feed intake, rate of gain, gain efficiency, carcass traits and cost of gain were not different among treatments. The retail shelf-life display study determined that the high (40 percent) forage diet maintained baseline beef color longer than the low (20 percent) forage diet.

Summary

The objective of this study was to evaluate the effect of feeding different levels of forage during the finishing phase of beef production. Steer performance and meat quality traits were evaluated.

One hundred twenty steers were fed a finishing diet that consisted of a corn and barley combination, with treatments being different forage content of 20 percent (20FOR), 30 percent (30FOR) or 40 percent (40FOR) of the total ration. Body weight gains, average daily gains, dry matter intake and gain:feed were not different among treatments. Hot carcass weight, rib-eye area, 12th rib fat thickness, marbling and final yield grades were not different among treatments. Shelf-life evaluations showed that loin steak redness (a*) was greater from day six to day 10 of the shelf-life display study for the 40 percent forage diet when compared with other treatments. Steak yellowness (b*) had a tendency to be greater for the 40 percent forage diet as well. These results indicate that when compared with 20 and 30 percent forage diets, the 40 percent forage treatment resulted in meat that maintained a fresher appearance longer. The cost of producing a pound of gain was only slightly different among treatments and would have very little impact on overall profits.

Introduction

Because of the increased cost of grain, beef producers are looking for alternative feedstuffs as a way to reduce costs. One way may be to increase forage in a high-concentrate finishing diet. Adding a low percentage of forage to finishing diets helps prevent digestive upsets and, therefore, maximizes energy intake (Gaylean and Defoor, 2003).

Bartle and Preston (1991) found that reducing roughage content during the midfinishing period may improve carcass quality. Willms et al. (1991) fed cattle a finishing diet of 10 or 20 percent forage and determined that 12th rib fat thickness; kidney, pelvic and heart fat; and yield grade were not different between treatments. They did report that rib-eye area tended to be larger in steers fed 10 percent forage than those fed 20 percent forage. They had no explanation for the difference in rib-eye area.

For the present study, we also conducted a shelf-life display study to compare color stability among treatments. Visual appearance is the most important sensory property by which consumers judge meat quality (Kropf et al., 1986). The objective of this study was to evaluate three different diets that contained 20, 30 or 40 percent forage and to assess effects on growth performance and meat quality traits.

Experimental Procedures

This study was conducted at the Carrington Research Extension Center in outside feedlot research pens. The protocol for this study was approved by the NDSU Animal Care and Use Committee.

One hundred twenty steers were stratified by body weight (BW) and then allotted randomly to one of 12 pens (n = 10 head/pen). Dietary treatments were forage level in finishing rations (Table 1). All steers were fed a 40 percent forage diet for the first 28-day period and then assigned to one of three treatments: 1) 40 percent forage (40FOR), 2) 30 percent forage (30FOR) or 3) 30 percent forage for 28 days and then 20 percent forage throughout the remainder of the feeding periods (20FOR). Diets contained 8 percent hay with increasing corn silage (assuming 100 percent forage) in the higher percentage forage treatments.

Steers were weighed approximately every 28 days for a total of 119 days. Performance data collected included average daily gains, dry-matter intake and gain:feed. Steers were slaughtered on one day at Tyson Fresh Meats in Dakota City, Neb. Hot carcass weights were obtained on slaughter day. The following carcass attributes were measured after a 24-hour chill: 12th rib fat depth; rib-eye area; kidney, pelvic and heart fat (KPH); marbling; and U.S. Department of Agriculture yield grades.

Beef strip loins were obtained from the carcasses, vacuum-packaged and transported to the NDSU Meats Laboratory and aged for 10 days at a temperature of 39 F. At day 10, three steaks (about 1 inch) were cut from the strip loins. Steaks were vacuum-packaged individually and frozen until further evaluation of tenderness or prepared immediately for retail display.

Retail display shelf-life steaks were placed on metal trays, covered with polyvinyl chloride film and placed under continuous fluorescent lighting at 39 F. Steaks were evaluated for color scores with a Minolta chromometer (model CR-410, Konica Minolta, Osaka, Japan) every 24 hours and rotated randomly. Muscle lightness (L*), muscle redness (a*) and muscle yellowness (b*) color scores were recorded for 10 days.

Strip loin steaks used for the tenderness evaluation were thawed for 24 hours at 39 F. Warner-Bratzler shear force analysis was conducted according to American Meat Science Association guidelines (AMSA, 1995). The steaks were weighed and cooked on clamshell-style grills to an internal temperature of 160 F. Steaks were cooled to room temperature and weighed to determine cooking loss.

Six 0.5-inch cores from each steak were removed parallel to the muscle fibers and were sheared using a Warner-Bratzler shear force machine. The mean of the six cores per steak was used for analysis. Data were analyzed statistically using SAS GLM procedures (SAS Inc., Crary, N.C.). Pen was the experimental unit.

Results and Discussion

Feedlot Performance and Carcass Traits

Measures of growth performance (Table 2) were not different among treatments ($P \geq 0.14$). The feed cost per pound of gain wasvery similar across all treatments. This indicated the cost among the diets would have very little impact on overall profit. These results agree with Bartle et al. (1994), who found average daily gains were not affected as forage level increased from 10 to 20 percent.

Hot carcass weights, rib-eye area, 12th rib fat thickness, kidney-pelvic-heart fat, marbling score and USDA yield grade were all similar among treatments ($P \geq 0.61$). Previous studies have shown similar results (Arnett et al., 2012; Willms et al., 1991). Warner-Bratzler shear force and cook loss also were not different ($P \geq 0.26$) among treatments (Table 3).

Shelf-life Display

During shelf-life display, steak lightness (L*) was similar among treatments for the 10-day study (Figure 1). Steak redness (a*) was significantly higher for the 40 percent forage diet after day six (Figure 2). This indicates the higher forage diet resulted in meat that stayed redder longer. Steak yellowness (b*) had a tendency to be higher for the 40 percent forage diet when compared with the other treatments (Figure 3).

A study done by Arnett et al. (2012) found similar results when feeding steers a finishing diet of 12 or 24 percent forage. Their results showed that during retail shelf display, steaks from steers fed 12 percent forage were less red and yellow than steaks from steers fed a 24 percent forage diet. These results could be due to forages being rich in antioxidants, which can contribute to the delay of oxymyoglobin and lipid oxidation in meat, resulting in extended color stability for beef (Liu et al., 1995). We did not measure dietary antioxidant concentrations.

This study indicates that finishing diets with greater amounts of forage do not influence body weights, carcass composition, meat quality or tenderness, and did not decrease cost of gains. However, meat color attributes were improved.

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Table 1. Finishing rations for steers fed different levels of forages.

	Diet Treatments		
Feeds	40FOR	30FOR	20FOR
	Percent, Dry-matter basis		
Prairie hay	8.0	8.0	8.0
Corn silage	32.0	22.0	12.0
Corn #2	18.5	23.5	28.5
Barley	18.5	23.5	28.5
Modified distillers grains	20.0	20.0	20.0
Calcium carbonate	1.0	1.0	1.0
Supplement			
Rumatec Sup – 1/3 lb.	2.0	2.0	2.0
Nutrients			
Dry matter, %	53.7	59.1	65.7
Net energy gain, Mcal/lb.	56.9	59.0	61.1
Crude protein, %	13.2	13.4	13.2
Calcium, %	0.71	0.69	0.67
Phosphorous, %	0.31	0.32	0.34
Potassium, %	0.72	0.67	0.61

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Potassium, %	0.72	0.67	0.61

Table 2. Performance of yearling steers fed different levels of forages as part of finishing rations.

Item	Treatments				
	40FOR	30FOR	20FOR	StErr	*P*-Value
Number of pens	4	4	4		
Number of animals	40	40	40		
Body weight, lbs.					
Initial wt., Oct. 8	861	865	862	21	0.98
Final wt., Feb. 22	1383	1399	1393	28	0.92
Avg. daily gain, lbs.	4.08	4.25	4.26	0.10	0.39
Dry-matter intake, lbs./head/day	27.5	27.7	28.1	0.57	0.71
Gain:feed, (DM)	0.14	0.14	0.13	0.003	0.14
Feed costs/lb. gain	$0.70	$0.69	$0.71		

Table 3. Carcass traits of steers fed different levels of forages as part of finishing rations.

	Treatments				
	40FOR	30FOR	20FOR	St Err	*P*-Value
Hot carcass wt., lb.	817.41	831.75	825.20	37.8	0.87
Rib-eye area, sq. in.	13.44	13.69	13.71	0.67	0.82
Backfat thickness, in.	0.45	0.45	0.43	0.05	0.90
KPH, %	2.42	2.44	2.52	0.20	0.74
Marbling score[a]	350	340	354	20	0.61
Yield grade[b]	2.91	2.89	2.84	0.18	0.86
WBSF, lbs.	6.50	5.82	6.48	0.29	0.26
Cook loss, %	19.47	18.30	17.94	3.43	0.89

[a]Based on scores 300-399 = small and USDA low Choice quality grade
[b]Yield grade is composite calculation of fat to lean yield in a carcass based on a relationship of hot carcass wt., rib-eye area, fat thickness and KPH, low values = lean carcasses

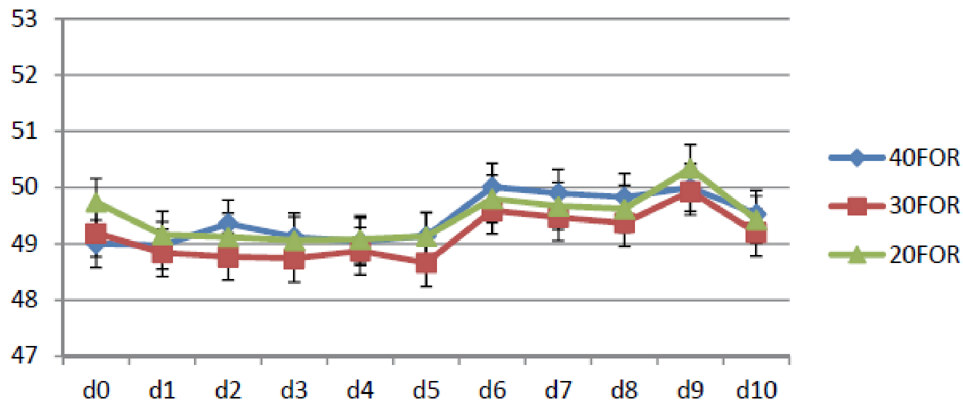

Figure 1. L* color measurements over 10d period from strip steaks from steers fed different forage levels as part of finishing rations.

*Means between 40FOR and 30FOR or 20FOR are different ($P < 0.05$)

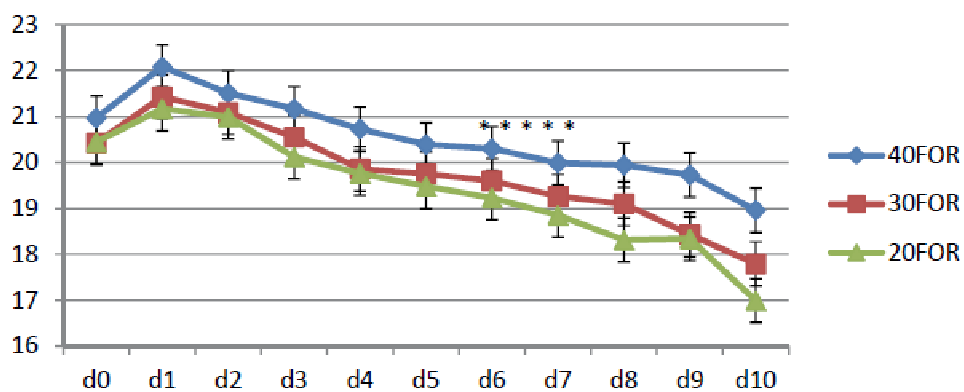

Figure 2. a* color measurements over 10d period from strip steaks from steers fed different forage levels as part of finishing rations.

*Means between 40FOR and 30FOR or 20FOR are different ($P < 0.05$)

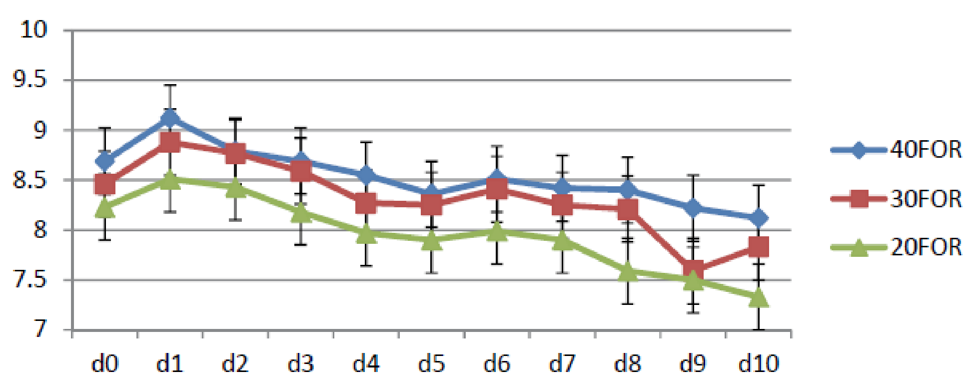

Figure 3. b* color measurements over 10d period from strip steaks from steers fed different forage levels as part of finishing rations.

*Means between 40FOR and 30FOR or 20FOR are different ($P < 0.05$)

Effects of natural service and artificial insemination breeding systems on calving characteristics and weaning weights

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A similar proportion of females exposed to estrous synchronization (ES) and artificial insemination (AI) became pregnant during the breeding season, compared with females mated during a natural service (NS) breeding system. Females in a breeding system that included ES and AI calved earlier in the calving season, compared with females mated with natural service, and a weaning weight advantage was observed in AI calves born within the first 21 days of the calving season, compared with NS calves born within the first 21 days of the calving season.

Summary

Crossbred Angus beef cows and heifers (n = 480 and 86, respectively) were used to compare the effects of two breeding systems on calving characteristics and weaning weights. Cattle were assigned randomly to one of two treatments: 1) exposed to natural service bulls (NS; n = 284) or 2) exposed to estrous synchronization and a fixed-time artificial insemination (AI), followed by natural service bulls (TAI, n = 282). A greater proportion ($P < 0.05$) of TAI females (54.2 percent) gave birth in the first 21 days of the calving season, compared with the NS treatment (39.5 percent). From day 22 to 42, a greater ($P < 0.05$) proportion of females in the NS treatment (34.3 percent) gave birth, compared with cattle in the TAI treatment (18.8 percent). No differences ($P > 0.05$) were present among treatment in the proportion of females that calved after day 43 or failed to have a calf. Overall, the mean calving date for females in the TAI treatment (day 17.6) was seven days earlier ($P < 0.01$) than that of females in the NS treatment (day 24.6). Calves born in the AI treatment were lighter ($P < 0.05$) at birth, compared with calves in the NS treatment. A 19.4-pound weaning weight advantage ($P < 0.05$) was observed in AI calves born within the first 21 days of the calving season, compared with NS calves born within the first 21 days of the calving season.

Introduction

Incorporating estrous synchronization (ES) and artificial insemination (AI) into beef operations may result in improved reproductive performance, weaning weight, carcass quality and genetic value, along with reduced calving difficulty (Sprott, 2000). Experiments have used cleanup bulls after the use of ES and AI (Geary et al., 2001; Stevenson et al., 1997) but do not utilize the use of a traditional breeding system as a control. We reported that no differences in season-ending pregnancy rates existed among groups that were assigned to a natural service (NS) breeding system or a breeding system that incorporated AI (Steichen et al., 2012).

Ultrasound was used to determine the fetal age of all pregnancies in the previous study, and females in the AI treatment became pregnant earlier in the breeding season, compared with females in the NS treatment. The objectives of the current study were to compare the effects of natural service and artificial insemination breeding systems on calving characteristics and weaning weights.

Experimental Procedures

Crossbred Angus cows and heifers were used in two locations: 1) Central Grasslands Research Extension Center (n = 86 heifers and n = 405 cows) and 2) Hettinger Research Extension Center (n = 81 cows). Females were assigned to one of two treatments: 1) exposed to natural service bulls (NS, n = 284) or 2) exposed to ES and fixed-time AI (day 0), followed by natural service bulls (TAI, n = 282).

Females in the TAI treatment were synchronized with the seven-day CO-Synch + CIDR protocol (Beef Reproductive Task Force, 2013). Bulls were introduced to the herd on day one, and both treatments were managed as a cohort in the same pastures. The breeding season for the CGREC and HREC was 49 and 63 days, respectively.

Calving began at the CGREC on March 14, 2012, /and at the HREC on April 3, 2012. Date, calving ease, calf vigor and birth weights were recorded at calving. Calving ease and calf vigor were determined subjectively. Calving ease was rated on a 1 to 5 scale, with 1 being no assistance and 5 being caesarean. Calf vigor was rated on a scale of 1 to 5, with 1 being a normal, vigorous calf and 5 being a stillbirth.

All calves were managed on the same pastures as a cohort. Calf weights were collected at weaning (Sept. 14, 2012). For purposes of analyzing calving and weaning data, calves were grouped into 21-day intervals according to birth date within the calving season (about 21 days, 22 to 42 days and more than 42 days).

All data were analyzed using the GLM procedures of SAS (SAS Ins. Inc., Cary, N.C.). The statistical model included the effects of treatment, calving group, location and the respective interactions. Significance was determined with an alpha of $P < 0.05$.

Results and Discussion

The pregnancy rate (overall 55 percent of TAI became pregnant to AI) and days to conception data were reported in the "2012 North Dakota Beef Report" (Steichen et al., 2012). During the calving season, a greater proportion ($P < 0.05$) of TAI cattle gave birth in the first 21 days of the calving season, compared with the NS treatment (Figure 1). From day 22 to 42, more females in the NS treatment ($P < 0.05$) gave birth, compared with cattle in the TAI treatment.

No differences ($P > 0.05$) were evident among treatment in the proportion of females that calved after day 42 or failed to have a calf (NC, either were classified as nonpregnant at final pregnancy diagnosis or failed to calve between the final pregnancy diagnosis and the end of the calving season).

The mean calving date for females in the TAI treatment (day 17.6) was seven days earlier ($P < 0.01$) than that of females in the NS treatment (day 24.6). This relative difference was similar to that anticipated after our original pregnancy diagnosis and fetal aging via ultrasound (Steichen et al., 2012).

The length of the calving season was similar ($P > 0.10$) between the two treatments. Similarly, Rodgers et al. (2012) reported the mean calving date was shifted earlier by incorporating ES and AI, but the length of the calving season was not different, compared with that of the natural service treatment. Calving season length is determined by the length of bull exposure and was not influenced by incorporating AI in the current study.

Calves born in the TAI treatment were lighter ($P < 0.01$) at birth (82.2 pounds), compared with calves born in the NS treatment (85.1 pounds). The anticipated reduction in birth weight because of slight expected progeny differences (EPD) of bulls among treatments would have been 0.6 pound.

The realized difference among treatments was greater, however, giving a greater advantage to calves born in the AI treatments. Even though a birth weight advantage did exist, primarily for calves that were sired by AI sires, calving ease and vigor were not different ($P > 0.10$) among treatments.

Overall, the average weaning weight of calves was 452 pounds at an average age of 150 days (five months). Calves born in the AI treatment during the first 21 days of the calving season were 19.4 pounds heavier at weaning ($P < 0.05$) than those born during the first 21 days of the calving season in the NS treatment (Figure 2). Calves that calved later in the calving season were progressively lighter at weaning, compared with their earlier-born counterparts. However, no differences among treatments ($P > 0.10$) were present within the two remaining calving groups analyzed (22 to 42 and greater than 42 days, respectively).

Because the same bulls that sired the natural service calves were used as cleanup bulls to the AI breeding, no differences in weaning weight of later-born calves was expected. The weaning weight advantage of AI calves born during the first 21 days of the calving season highlights the potential gain producers can receive if they choose proven bulls with high growth potential.

Incorporating artificial insemination and estrous synchronization altered the calving season by having a greater proportion of cattle give birth earlier in the calving season to lighter calves. The advantage of artificial insemination also was observed in the weaning weights of calves born within the first 21 days of the calving season. Subsequent studies will compare additional postweaning performance traits among TAI and NS treatments.

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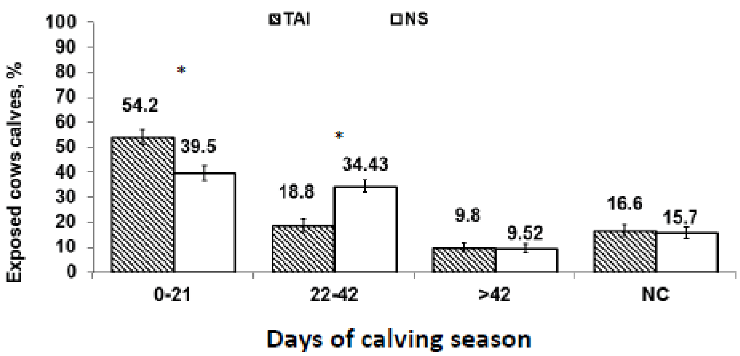

Figure 1. Effect of treatment on calving distribution.

*Means within factor lacking common superscript differ ($P < 0.05$).
NC, either was called open at final pregnancy check or pregnant but did not calf.

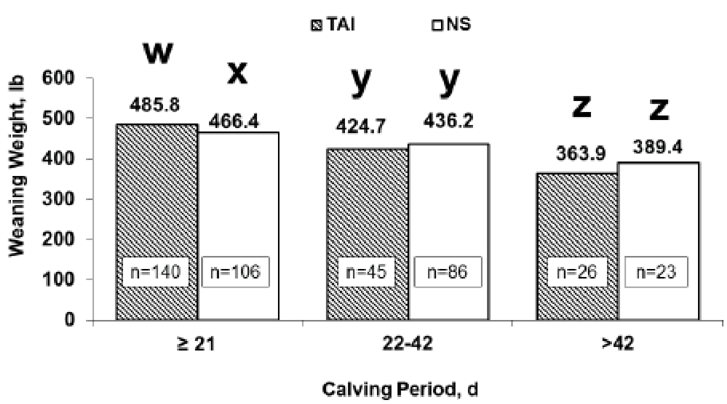

Figure 2. Effect of treatment and calving period on weaning weight of calves

Treatment × Calving period interaction ($P < 0.001$).
w,x,y,z Means lacking common superscript differ ($P < 0.05$).

Sheep

Research Report

Hettinger Research Extension Center
Department of Animal Science
North Dakota State University
Report No. 53

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Analysis of a Sheep Cover Crop Grazing Trial in Southwestern North Dakota[1]

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[1]This project was partially support by the National Research Initiative of the USDA Cooperative State Research, Education, and Extension Service, grant number 2005-55618-15754 and by a USDA Five State Ruminant Consortium Grant. We would like to thank Drs. Jack Norland and Kevin Sedivec for their edits.

The objective of this study was to evaluate forage production and potential for late-season sheep gains on a single-cropped cover crop planting in Southwestern North Dakota in hopes to increase forage availability later into the fall and subsequently reduce feedlot dependency. Our research suggests there was little difference in ewe body weight gain for ewes grazing two cover crop mixtures, but ewes grazing mixed-grass prairie exhibited a significant reduction in ADG when compared to the ewes grazing cover crops.

SUMMARY

Determining forage value and potential livestock production from cover crop plantings gives sheep producers an alternative to supplemental feeding of ewes grazing rangelands or being forced to enter into drylot feeding, hopefully decreasing both labor and feed costs. Cover crops provide numerous environmental benefits, including soil health improvements, increased soil moisture for future crop yields, and as an excellent food and cover source for many wildlife species. Although cover crops have related expenses, the environmental benefits, coupled with the availability of late-season forage, may make them appealing to farm/ranch operations.

During this study, bred brood ewes were placed in one of nine different paddocks with a total of three different treatments during October (2010, 2011, and 2012). Treatments consisted of two different spring cover crop plantings and an idled mixed-grass prairie paddock that served as a control. Ewes gained an average of 0.28 lbs/day on the cover crop plantings and lost approximately 0.03 lbs/day on the mixed-grass control. Our research suggests that standing cover crops can provide substantial forage with adequate nutritional value to bred ewes to length the grazing season, delaying the onset of supplemental feeding or entry into the drylot.

INTRODUCTION

Finding ways to increase the length of the grazing system is a common way for livestock managers to reduce feed costs (Adams et al., 1994). Grazing annual forages as a supplemental late-season food source for livestock can serve as a way to increase the grazing season while providing high-quality forages for livestock (Neville et al., 2008). Cover crops have grown in popularity across much of the US as a way to provide multiple benefits to farm lands, including nutrient cycling efficiency and soil and water conservation (Franzluebbers and Stuedemann, 2006). Livestock grazing of cover crops has had variable effects on soil quality and subsequent crop production, but overall has shown increased economic returns and diversity (Franzluebbers and Stuedemann, 2006; Bell et al., 2011). Our study assessed the forage suitability of two different cover crop mixes compared with mixed-grass prairie for gestating Rambouillet ewes.

PROCEDURES

All procedures were approved by the NDSU Animal Care and Use Committee. The study was conducted at the Hettinger Research Extension Center near Hettinger, North Dakota, in Adams County. The study area receives approximately 16 inches of precipitation annually, with the average summer temperature (June through August) approximately 66°F (NDAWN, 2012).

Grazing Treatments. The grazing study utilized three different treatments randomly allotted to 9 paddocks (1.6 ac; n = 3): cover crop treatment 1, designed as a species mixture targeting pollinators (insects), wildlife, and soil health benefits (**CC1**), cover crop treatment 2, designed as a forage crop for livestock and for soil health benefits (**CC2)**, and the mixed-grass range control consisting of smooth bromegrass, crested wheatgrass, and alfalfa (**CON**). The CC1 treatment utilized seed mixtures containing 16, 9, 2, 2, 1.6, 1, and 0.6 lb/ac for oats, forage soybean, Proso millet, milo, purple-top turnip, sweet clover, and forage radish, respectively ($26.36/ac.). The CC2 treatment utilized planting rates of 3.6, 3, and 1.6 lb/ac for purple-top turnips, Proso millet, and forage radish, respectively ($22.22/ac). CC1 and CC2 treatments were annually sprayed with glyphosate prior to planting. Planting occurred in mid-June, with fertilizer (11-52-0) applied to both CC1 and CC2 at 50 lb/ac at the time of planting.

Vegetative data was collected at the onset of the research trial during each of the three years. Peak production was determined in late-July in each paddock by species for each species present using nine 1/4 m^2 frames per paddock and extrapolated to determine average total lbs/ac/species for each treatment. Concurrently, vegetation clippings were dried and sent to Midwest Laboratories Inc. for nutrient analysis.

Animals. One hundred and eight Rambouillet ewes bred to lamb approximately on January 15 were utilized to evaluate livestock performance. Two-day weights were taken at the beginning and end of the grazing period. Ewes were stratified by weight and randomly assigned to one of 9 paddocks (12 ewes per paddock). Each of the nine paddocks was grazed for approximately 30 days in October during 2010, 2011, and 2012.

Statistical Analysis. Data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc, NC). Paddock served as the experimental unit (n = 3). The covariance structure was Autoregressive. The fixed effect included in the model was treatment. Treatment, year, and treatment x year interactions were evaluated. When a significant F-test was observed ($P \leq 0.05$), LS Means was used to partition effects. Significance was determined at $P \leq 0.05$. All interactions that were not significant were removed from the model.

RESULTS AND DISCUSSION

Animals and forage production. Treatment, year, and treatment x year effects are listed in Table 1. Average daily gain of pregnant Rambouillet ewes was significantly affected ($P = 0.02$) by treatment, with a treatment by year interaction ($P = 0.91$) present, and a year effect ($P < 0.01$). Average daily gain was higher for CC1 and CC2 than CON (0.27, 0.30, and -0.03 lb/d, respectively). Forage quantity did not appear to be the reason for this difference, as no effects were observed for treatment, year, or treatment x year ($P \geq 0.76$).

Nutrient Analysis. Nutrient analysis of CC1, CC2, and CON are listed in Table 1. Treatment x year interactions were observed ($P \leq 0.02$) for CP, TDN, NE_m, and NE_g. While variable across years, CC1 and CC2 tended to have higher CP concentrations relative to CON (11.84, 12.04, and 5.9%, respectively). This largely explains differences in body weight gains across treatments, as energy (expressed as TDN, NE_m, and NE_g) was not affected by treatment ($P \geq 0.19$), even though it was variable across the treatment x year interaction ($P \leq 0.01$). Additionally, ADF was greater ($P < 0.01$) for CON (44.97%) compared to CC1 and CC2 (30.94 and 27.99%, respectively), further explaining differences in performance.

Mineral Analysis. Treatment x year interactions were observed for Ca and Cu ($P \leq 0.02$). Similar to nutrient concentrations, variability existed between years, especially for the cover crop treatments (Table 1). However, CON had consistently lower Ca and Cu concentrations than CC1 and CC2. This trend for increasing concentrations of minerals in cover crop treatments is also present for S, P, K, Mg, and Zn, which exhibited a treatment effect ($P \leq 0.03$). However, two minerals, Fe and Mn exhibited a treatment effect ($P \leq 0.03$) in which CON was similar ($P \geq 0.05$) to either CC1 or CC2. In general, the cover crop treatments resulted in mineral concentrations that would be expected for grain-type annual forages, of which many were present in the cover crop plant seeding mixtures.

IMPLICATIONS

Cover crop plantings, either targeting wildlife use or forage for livestock, resulted in ADG in pregnant ewes that were significantly higher than when ewes grazed mixed-grass prairie in the early fall. These results suggest further research should be conducted to determine optimal planting mixtures and timing of grazing of cover crops being utilized as soil health amendments, wildlife habitat, and forage for sheep grazing.

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Table 1. Sheep production, vegetative biomass production, and feed nutrition analysis from a sheep cover crop grazing trial in Adams County, North Dakota, October 2010, 2011, and 2012[1]

	Cover Crop 1[2]				Cover Crop 2[3]				Mixed-Grass Prairie[4]					*P*-value		
Items	2010	2011	2012	Avg	2010	2011	2012	Avg	2010	2011	2012	Avg	SEM^{Trt}	Trt	Yr	Trt*Yr
ADG, #/d	0.66	-0.04	0.18	0.27^{x}	0.70	-0.09	0.30	0.30^{x}	0.42	-0.49	-0.03	-0.03^{y}	0.08	0.02	<0.01	0.91
Biomass, #/ac.	1966	2317	2356	2213	2200	1900	2252	2117	1982	1845	2015	1947	255	0.76	0.84	0.96
Nutrient Analysis																
CP, %	14.72^{de}	10.33^{bc}	10.49^{bcd}	11.84	15.17^{e}	7.97^{ab}	13.00^{cde}	12.04	6.22^{ab}	5.59^{a}	5.89^{a}	5.90	0.84	<0.01	0.13	0.02
Crude Fat, %	1.88	2.28	2.50	2.22	1.54	1.80	1.77	1.70	1.91	2.45	1.56	1.98	0.21	0.09	0.61	0.43
ADF, %	24.2	33.4	35.23	30.94^{y}	23.00	29.2	31.77	27.99^{y}	43.17	44.33	47.4	44.97^{x}	1.82	<0.01	0.13	0.65
Ash, %	11.06	8.04	6.08	8.93^{x}	12.13	7.07	8.79	9.33^{x}	8.44	6.19	6.32	6.98^{y}	0.47	<0.01	<0.01	0.11
TDN, %	63.07^{ab}	65.07^{cd}	66.33^{de}	64.82	62.23^{a}	66.83^{e}	64.03^{abc}	64.37	64.07^{bc}	65.90^{cde}	65.07^{cde}	65.01	0.37	0.21	0.02	<0.01
NE_M, Mcal/lb	0.64^{ab}	0.67^{cd}	0.69^{de}	0.66	0.63^{a}	0.69^{e}	0.66^{abc}	0.66	0.66^{bc}	0.68d^{e}	0.67cd^{e}	0.67	0.01	0.19	0.03	<0.01
NE_G, Mcal/lb	0.37^{ab}	0.40^{cd}	0.42^{de}	0.39	0.35^{a}	0.42^{e}	0.38^{abc}	0.39	0.38^{bc}	0.41^{ed}	0.40^{cde}	0.40	0.01	0.21	0.01	<0.01
Mineral Analysis																
S, %	0.343	0.313	0.143	0.27^{xy}	0.483	0.247	0.447	0.39^{x}	0.113	0.103	0.090	0.10^{y}	0.064	0.02	0.58	0.50
P, %	0.310	0.247	0.217	0.26^{x}	0.357	0.340	0.260	0.32^{y}	0.150	0.130	0.080	0.12^{z}	0.016	<0.01	0.01	0.86
K, %	2.71	1.98	1.55	2.08^{x}	2.70	1.77	1.65	2.04^{x}	0.52	0.54	0.22	0.43^{y}	0.11	<0.01	<0.01	0.15
Mg, %	0.420	0.350	0.333	0.37^{x}	0.523	0.313	0.393	0.41^{x}	0.117	0.157	0.093	0.12^{y}	0.040	<0.01	0.51	0.20
Ca, %	2.26^{b}	0.76^{a}	0.54^{a}	1.19	2.87^{b}	0.58^{a}	0.97^{a}	1.48	0.47^{a}	0.61^{a}	0.39^{a}	0.49	0.15	<0.01	<0.01	<0.01
Na, %	0.025	0.043	0.005	0.02	0.085	0.028	0.080	0.06	0.005	0.005	0.005	0.01	0.021	0.17	0.90	0.77
Fe, ppm	101.3	85.67	196.7	127.9^{y}	195.0	140.3	375.3	236.9^{x}	135.7	107.0	249.3	164.0^{y}	22.33	0.01	0.01	0.54
Mn, ppm	47.7	51.7	50.0	49.78^{y}	104.3	52.0	90.7	82.33^{x}	87.3	63.0	91.7	80.0^{x}	9.84	0.03	0.38	0.31
Cu, ppm	3.00^{abc}	3.67^{bcd}	6.00^{f}	4.22	4.33^{cde}	4.67^{def}	5.67^{ef}	4.89	2.67^{ab}	3.00^{abc}	2.00^{a}	2.56	0.28	<0.01	0.03	0.02
Zn, ppm	28.0	24.0	27.3	26.44^{y}	37.33	43.00	34.33	38.22^{x}	23.33	20.00	26.67	23.33^{y}	3.10	0.03	0.99	0.77

[1]Bolded items indicate main and interaction effects with highest order of significance.
[2]Cover crop mixture for pollinators (insects), wildlife, and soil health benefits (**CC1**).
[3]Cover crop mixture for livestock forage and soil health benefits (**CC2).**
[4]Mixed-grass prairie consisting of smooth bromegrass, crested wheatgrass, and alfalfa (**CON**).
^{a,b,c,d,e} Means within a row, with a significant Trt*Yr interaction, without a common superscript differ ($P \leq 0.05$).
^{x,y,z} Means within a row, with a significant Trt effect, without a common superscript differ ($P \leq 0.05$).

Influence of the level of dried distillers grains with solubles on feedlot performance, carcass characteristics, blood metabolites, and semen quality of growing rams[1]

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The objectives of this research were to determine the influence of dried DDGS on feedlot performance, carcass characteristics, semen quality, and testosterone concentrations of growing rams. Results indicate that semen quality may be affected by increasing concentrations of DDGS in rations fed to growing rams.

INTRODUCTION

In the past 10 years, ethanol production has increased from 1.5 million gallons per year to approximately 9 million gallons per year in the United States (Renewable Fuels Association, 2010). With this expansion brings an affordable and viable feed source for ruminants, dried distillers grains with solubles (DDGS). Anecdotal reports from the feed industry have reported that growing bulls and rams should not be fed DDGS, due to a fear of a negative effect on reproductive performance. To our knowledge, there is no research currently available describing the effect of DDGS feeding on male reproductive performance.

Research involving the feeding of DDGS to ruminants has become more prominent in the past few years due to the rising costs of feedstuffs, particularly corn. Compared with non-supplemented heifers, dried distiller's grains supplemented heifers had increased ADG and reduced forage intake (MacDonald et al., 2007). However, during the growing and finishing phase DDGS fed to steers at 30% of the diet did not affect any performance variable or carcass characteristic (Leupp et al., 2009). Similarly, Schauer et al. (2008) and Neville et al. (2010) observed no negative effects on finishing lamb performance or carcass characteristics when fed DDGS at 60%.

While we are not aware of research evaluating the effects of DDGS feeding on male reproductive performance, there is some research available on feeding increased dietary CP to growing males (an artifact of increasing DDGS in rations, as DDGS is relatively high in CP). Rams fed a high energy and protein diet had increased testosterone concentrations at the beginning of the trial, but as the trial duration increased, the differences in testosterone concentrations were reduced (Martin et al., 1994). Hotzel et al. (1998) observed an increase in testosterone concentrations in Merino rams fed a diet above maintenance requirements.

Therefore, we hypothesized that feeding increasing levels of DDGS would have no deleterious effects on ram feedlot performance, carcass characteristics, and semen quality, but would increase testosterone concentrations.

PROCEDURES

All procedures were approved by the Animal Care and Use Committee of North Dakota State University. This study was conducted at the Hettinger Research Extension Center in Hettinger, North Dakota.

Animals and Diets. One hundred twenty crossbred rams (western whiteface x Suffolk; approximately 90 d of age) were used in a completely randomized design to determine the effects of DDGS on feedlot performance, carcass characteristics, semen quality, and testosterone concentrations of growing rams. Rams were allotted into one of four dietary treatments (n = 4 pens/treatment; 10 rams/pen; Table 1): 1) **CON**: 85% corn and 15% commercial market lamb pellet; 2) **15DDGS**: 15% DDGS substituted for corn (DM basis); and 3) **30DDGS**: 30% DDGS substituted for corn (DM basis). Rams were fed a ground ration (grinder-mixer) ad-libitum via self-feeders. Rams had continuous access to water and shade. Rams were weighed on two consecutive days at the beginning (d 0, 1) and end of the trial (d 96, 97 and d 116, 117), and weighed on a single day every 28 d. Scrotal circumference was measured on d 84, 96, and 116 of the trial. Two slaughter dates were utilized for the trial. The first slaughter date included all rams weighing at least 67 kg except those involved with the semen quality and testosterone portions of the trial. The second slaughter date included all remaining rams on trial. At completion, rams were shipped to Superior Farms in Denver, CO for carcass data collection. One ram was removed from the trial prior to being shipped for slaughter due to non-treatment related purposes (antibiotic withdrawal time).

Semen Quality. Semen was collected on forty-eight rams (a sub-sample of the 120 rams in the feedlot study described above; 4 rams/pen; 16 rams/treatment; n = 4). Semen from each of the rams was collected on d 84, 98, and 112 of the study. Motility, a subjective motility score, and concentration of sperm in the ejaculate via a hemocytometer on the fresh ejaculate sample were used to determine semen quality.

Testosterone. The forty-eight rams (4 rams/pen; 16 rams/treatment; n = 4) utilized in semen collection were used to collect testosterone concentrations. Blood samples were collected via a 20 gauge x 1 inch vacutainer needles into serum separator 16 x 100 mm tubes. Every 14 days throughout the duration of the trial, a 10 mL blood sample was collected via jugular venipuncture of each ram and immediately placed on ice until serum could be harvested post-centrifugation. Serum was frozen at -20ºC until analysis could be accomplished.

Statistical Analysis. Ram feedlot performance, carcass characteristics, and scrotal circumference were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Pen served as the experimental unit. The fixed effect included in the model was dietary treatment. The fixed effect of day was utilized in the REPEATED measures analysis for testosterone concentrations, spermatozoa concentration, and the subjective semen score. The model included the fixed effects of dietary treatment, week, and treatment x week. When a significant *F*-test was observed ($P \leq 0.15$), pre-planned comparisons of linear and quadratic contrasts were utilized to partition treatment effects. Significance was determined at $P \leq 0.05$. All interactions that were not clearly significant ($P \geq 0.20$) were removed from the model. To partition day effects and treatment × day interactions, LS Means was utilized ($P \leq 0.05$).

RESULTS AND DISCUSSION

Feedlot and Carcass Characteristics. Final BW and days on study were not affected ($P \geq 0.50$) by dietary treatment (Table 2). Average daily gain increased linearly ($P = 0.02$) with the addition of DDGS in the diet. Previous research has also suggested that lambs consuming rations containing DDGS have increased ADG compared with those lambs consuming no DDGS (Schauer et al., 2008). Overall, DMI increased linearly ($P < 0.001$) as the amount of DDGS was increased in the ration. These results are similar to those observed by Schauer et al. (2008) when DDGS inclusion was increased to 60% of the ration as a replacement for barley. However, G:F was reduced linearly ($P < 0.001$) with the inclusion of DDGS in the diet. Although there were some significant differences, the DDGS did not cause any overall deleterious effects on feedlot performance. This is indicated by the lack of differences in the amount of days on trial among the dietary treatments.

Hot carcass weight, dressing percentage, ribeye area, 12th rib fat thickness, body wall thickness, leg score, overall conformation, flank streaking, quality grade, yield grade, and percent boneless, closely trimmed retail cuts were not affected ($P = 0.26$; Table 2) by dietary treatment. These results were similar to Schauer et al. (2008) and Neville et al. (2010) in which there were no deleterious effects on carcass characteristics with DDGS inclusion in the diet.

Reproductive Traits. Change in scrotal circumference was not significant ($P = 0.61$) due to dietary treatment (Table 2). Contrary to the results in the current study, Martin et al. (1994) noted an increase in scrotal circumference in the high protein and energy fed rams compared with the low energy and protein fed rams. Hötzel et al. (1998) observed an increase in the change in scrotal circumference throughout the study in the rams fed to have increased rate of gain. Similar results were also observed in bulls, in which bulls fed increased energy diets (Coulter and Kozub, 1984). Although TDN was not different between diets, the CP of the diets increased with the increasing DDGS. Therefore, the results in the current study were not expected. There was a day effect ($P < 0.001$; Figure 1) for testosterone concentrations. This was expected as rams became more mature throughout the study; therefore, the testosterone concentrations would be expected to increase as the rams reached maturity. Testosterone concentrations were decreased in mature Merino rams fed a sub-maintenance diet compared with those fed a supra-maintenance (Hötzel et al., 1998). Martin et al. (1994) observed similar results to Hötzel et al. (1998), in which the high and intermediate energy and protein fed rams had increased testosterone concentrations compared with the low energy and protein fed rams.

Spermatozoa concentration decreased linearly ($P = 0.05$; Table 2) as DDGS increased in the diet. The rams fed the DDGS at both 15 and 30% had numerically reduced spermatozoa numbers compared with the rams that were not fed any DDGS. Coulter and Kozub (1984) observed a reduction in epididymal spermatozoa reserves and motility in bulls fed a high energy diet. The current results as well as previous research (Kozub and Coulter, 1984), may suggest increased protein and/or fat cause a reduction in spermatogenesis. This may be due to increased fat deposits around the seminiferous tubules. The spermatozoa motility score not affected (P = 0.23) by DDGS level (Table 2).

IMPLICATIONS

Much of the previous research with male reproductive performance has occurred in mature rams and bulls. Therefore, much of the data does not include growing rams as they approach and reach puberty. The current research suggests that feedlot rams can be fed up to 30% on DM basis of DDGS without causing deleterious effects to feedlot performance and carcass characteristics. However, care must be taken when feeding DDGS to growing rams due to a possible reduction in spermatozoa concentration, especially when included at 15% of the diet or higher. Further research is needed to elucidate why semen quality may be affected and if actual fertility of rams is compromised by feeding increasing concentrations of DDGS.

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Table 1. Ingredient and nutritional composition of diets fed to feedlot ram lambs (DM basis).

	Dietary Treatment[1]		
Item	CON	15DDGS	30DDGS
Ingredient, %			
Corn	85	70	55
DDGS[2]	—	15	30
Commercial market lamb pellet[3]	14.8	14.3	13.8
Calcium carbonate	0.2	0.7	1.2
Nutritional Composition, % DM			
TDN	84.6	84.6	84.3
CP	13.8	16.0	19.4
Ash	4.7	5.5	6.4
NDF	18	22.2	26.1
ADF	4.6	5.5	5.7
Crude Fat	2.3	3.7	4.6

[1]CON: 85% corn and 15% commercial market lamb pellet; 15DDGS: 15% DDGS substituted for corn on a % DM basis; and 30DDGS: 30% DDGS substituted for corn on a % DM basis.
[2]Dried distiller's grains with solubles.
[3]Commercial Market Lamb Pellet contained: 0.22 g/kg Chlortetracycline; 38.0% CP; 3.75-4.75% Ca; 0.6% P; 3.0-4.0% salt; 1.2 ppm Se; 52,863 IU/lb Vitamin A; 5,286 IU/kg Vitamin D; and 209 IU/kg Vitamin E.

Table 2. Effects of dried distiller's grains with solubles on feedlot performance and carcass characteristics of growing rams.

	Dietary Treatment[1]					*P*-value[4]	
Item	CON	15DDGS	30DDGS	SEM[2]	*P*-value[3]	Linear	Quadratic
Initial BW, lb	91.03	89.56	89.03	3.11	0.89	0.65	0.90
Final BW, lb	184.40	185.17	190.33	3.91	0.50	0.28	0.64
ADG, lb/d	0.96	0.98	1.04	0.02	0.06	0.02	0.52
DMI, lb/head/d	4.53	5.16	5.58	0.14	0.001	< 0.001	0.55
Days on study, d	109	108	107	1.59	0.54	0.27	0.90
G:F, lb of gain/lb of DMI	0.43	0.38	0.38	0.01	< 0.001	< 0.001	0.09
HCW, lb	91.91	93.74	93.82	2.46	0.81	0.57	0.77
Dressing %	49.95	50.41	50.13	0.37	0.67	0.72	0.41
REA, in^2	3.05	3.09	3.08	0.07	0.90	0.74	0.74
12th rib fat thickness, in	0.22	0.22	0.21	0.01	0.88	0.69	0.76
Bodywall thickness, in	1.05	1.11	1.13	0.04	0.26	0.11	0.70
Leg score[5]	11.60	11.98	11.69	0.25	0.54	0.80	0.29
Overall conformation[5]	11.60	11.96	11.80	0.21	0.47	0.49	0.32
Flank streaking[6]	350.79	374.88	356.86	11.57	0.30	0.70	0.14
Quality grade[5]	11.56	11.89	11.82	0.16	0.29	0.24	0.30
Yield grade	2.55	2.56	2.48	0.14	0.88	0.69	0.76
BCTRC,[7] %	44.98	44.73	44.87	0.30	0.84	0.79	0.60
Scrotal circumference change, in	0.59	0.49	0.68	0.74	0.61	0.65	0.39
Spermatozoa concentration[8]	91.8	69.3	63.0	10.17	0.13	0.05	0.52
Spermatozoa motility score[9]	3.3	2.8	2.7	0.23	0.23	0.12	0.52

[1]CON: 85% corn and 15% commercial market lamb pellet; 15DDGS: 15% DDGS substituted for corn (DM basis); and 30DDGS: 30% DDGS substituted for corn (DM basis).

[2]n = 4.

[3]*P* -value for the F test of the mean.

[4]*P*-value for linear and quadratic effects of increasing dried distillers grains with solubles.

[5]Leg score, conformation score, and quality grade: 1 = cull to 15 = High Prime.

[6]Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.

[7]Percent boneless, closely trimmed, retail cuts (% BCTRC) = [49.936 – (0.0848 × 2.204 × Hot Carcass Weight, kg) – (4.376 × 0.393 × 12th rib fat thickness, cm) – (3.53 × 0.393 × body wall thickness, cm) + (2.456 × 0.155 × LM area, cm2)].

[8]Spermatozoa concentrations were measured as hundreds of millions per milliliter. The hemocytometer has a counting chamber volume of 1 cubic millimeter. Five large squares were counted for each ejaculate sample, the four corner squares, and the middle square. To calculate the spermatozoa concentration: Total number of sperm counted x dilution factor x hemocytometer factor x conversion factor. The dilution rate was 1:200, the hemocytometer factor was 50, and the conversion factor (converted units to spermatozoa/cubic centimeter, or ml) was 1,000.

[9]Spermatozoa motility score: 1 = no forward movement to 4 = fast forward movement.

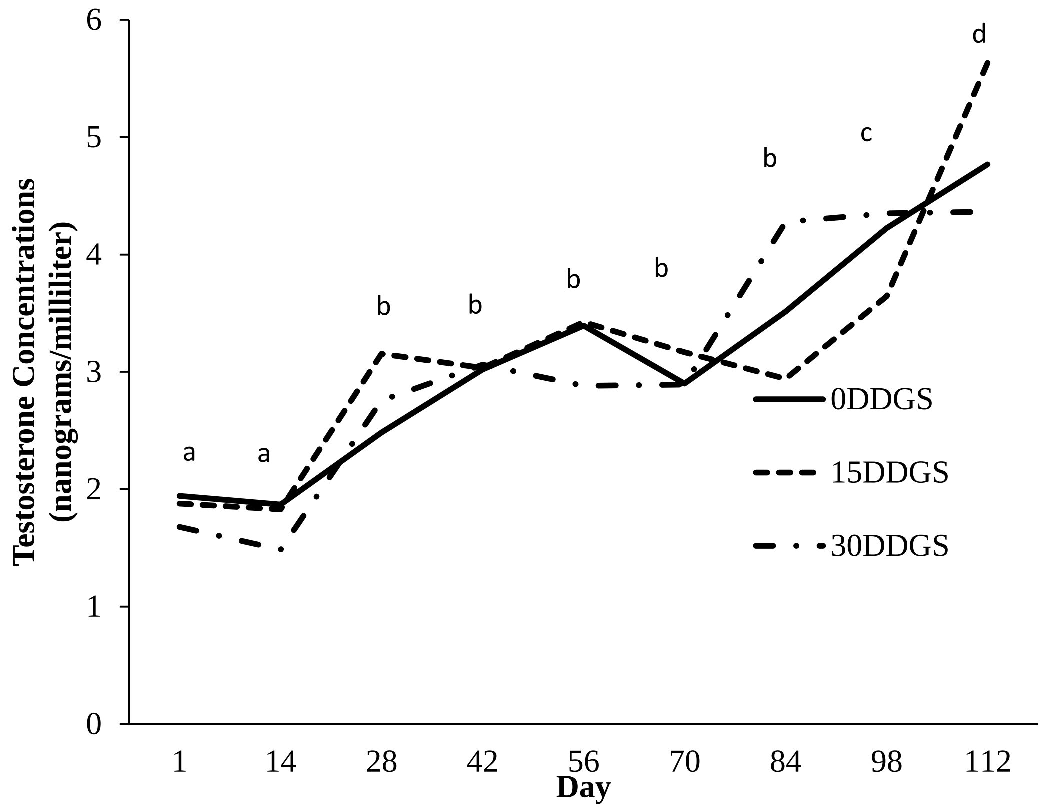

Figure 1. The effects of dried distillers grains with solubles on testosterone concentrations of growing ram lambs. Treatments included CON: 85% corn and 15% commercial market lamb pellet; 15DDGS: 15% DDGS substituted for corn (DM basis); and 30DDGS: 30% DDGS substituted for corn (DM basis). *P*-values: treatment, $P = 0.97$; day, $P < 0.001$; treatment x day, $P = 0.86$.

Placental development during early pregnancy in sheep: Effects of assisted reproductive technology on fetal and placental growth[1]

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Application of ART techniques decreased fetal size and cell proliferation in fetal and maternal placenta during early pregnancy. Thus, ART may have specific effects on growth and function of ovine maternal and fetal placenta and fetal tissues through regulation of cell proliferation and tissue growth, and likely other mechanisms.

SUMMARY

Assisted reproductive technologies (**ART**) may have profound effects on placental and fetal development, possibly leading to compromised pregnancy. To determine the effects of ART on the fetal size and cellular proliferation in maternal and fetal placental tissues, pregnancies were achieved through natural breeding (**NAT**), or transfer of embryos generated through in vivo (**NAT-ET**), in vitro fertilization (**IVF**), or in vitro activation (**IVA, clones**). On day 22 of pregnancy, tissues were collected and fetuses were measured. Then, expression of Ki67 (a marker of proliferating cells) was determined using immunohistochemistry followed by image analysis. Fetal length and labeling index (proportion of proliferating cells) in maternal and fetal placenta were less ($P<0.05$) in NAT-ET, IVF and IVF than in NAT. Thus, ART, including simply embryo transfer, may have deleterious effects on growth and function of ovine placental and fetal tissues through regulation of cell proliferation and tissue growth. These data provide a foundation for determining the expression of specific factors regulating placental and fetal tissue growth in pregnancies after ART application. In addition, these data will help us to better understand placental regulatory mechanisms in compromised pregnancies, and to identify strategies for rescuing such pregnancies.

INTRODUCTION

Early pregnancy is a critical period because of the major developmental events that take place, including embryonic organogenesis as well as formation of the placenta, a process known as placentation manifested by enhanced cell proliferation and vascular development (Mossman, 1937, 1987; Green and Winters, 1945; Boshier, 1969; Guillomot et al., 1981; King, 1982; Reynolds et al., 2002, 2006, 2010).

The pattern of placental growth during early pregnancy after natural breeding has been established for sheep (Zheng et al., 1996; Grazul-Bilska et al., 2010, 2011). Comparison of the development of placentas from natural pregnancies and pregnancies achieved by various assisted reproductive technologies (ART), such as after transfer of embryos created through in vitro fertilization (IVF) has demonstrated differences in placental and fetal growth in several species (Barnes, 2000; Cai et al., 2006; Grazul-Bilska et al., 2006; Romundstad et al., 2006; Allen et al., 2008; Collier et al., 2009; Delle Piane et al., 2010; Sellers Lopez et al., 2010; Esh-Broder et al., 2011; Tomic and Tomic, 2011). For early pregnancy in cows, both greater and less crown-rump length of fetuses created in vitro and then transferred compared to fetuses created in vivo has been reported (Bertolini et al., 2002; Farin et al., 2006). However, data concerning fetal and placental growth including cell proliferation in utero-placental tissues during early pregnancy established through ART application are very limited.

Factors influencing fetal and placental growth have a dramatic impact on fetal and neonatal survival and development (Reynolds and Redmer, 2001; Reynolds et al., 2002, 2006, 2010). Recent observations indicate that compromised fetal growth impacts not only the neonatal period but also life-long health and productivity in humans and livestock species (Nathanielsz 2006, Barker 2007).

We hypothesized that growth of maternal and fetal placenta, and fetus will be altered in pregnancies achieved through application of ART compared to natural pregnancies. In addition to our control group which was naturally bred (NAT), we chose three ART methods to establish pregnancies as follows: (i) superovulation induced by multiple injections of follicle stimulating hormone (FSH) combined with natural breeding, embryo flushing from donors and transfer to recipients (NAT-ET), (ii) transfer of embryos obtained through in vitro fertilization (IVF) of oocytes collected after induction of multiple follicular development using FSH, and (iii) transfer of embryos obtained through in vitro activation (IVA; i.e., parthenotes, which are clones containing only maternal genes) of oocytes collected from FSH-treated donors. In the NAT-ET group, embryos were only briefly removed from uterine environment and had maternal and paternal genomes, in IVF group embryos were created on culture dish and possessed both maternal and paternal genomes, but in IVA group embryos created on culture dish had only maternal genome. Parthenogenetic embryos are used to study the role of maternal genome and the effects of a lack of paternal genome on further embryonic development, imprinted genes and other processes in several species (Loi et al., 1998; Xu and Yang, 2001; Krivokharchenko et al., 2003; Kono et al., 2006; Ferrandi et al., 2002; Lagutina et al., 2004; Grazul-Bilska et al., 2008; Maalouf et al., 2008). The aim of this study was to determine fetal growth and cell proliferation in fetal and maternal placenta during early pregnancy in NAT, NAT-ET, IVF and IVA groups in sheep.

PROCEDURES

Animals and Tissue Collection. The NDSU Institutional Animal Care and Use Committee approved all animal procedures in this study. Estrus was synchronized for adult ewes (n=30;

crossbred Western Range, primarily Rambouillet, Targhee, and Columbia) using a CIDR device (MWI, Boise, ID) implanted for 14 days during breeding season. 24 h after CIDR removal, NAT ewes (n=8) were exposed to a fertile ram and naturally bred, but for NAT-ET (n=7), IVF (n=8) and IVA (n=7) groups estrus was checked twice daily using a vasectomized ram. 5%, 86% and 7% of ewes expressed estrus 24, 36 and 48 h after CIDR removal, respectively. Starting on day 13 of the estrous cycle, ewes from NAT-ET group were treated twice daily with FSH for 3 days but ewes from IVF and IVA groups were treated with FSH for 2 days (Stenbak et al., 2001; Grazul-Bilska et al., 2003, 2006; Borowczyk et al., 2006). On day 15 of the estrous cycle, ewes from NAT-ET group were exposed to a fertile ram for 24-48 h, but for IVF and IVA groups, ovaries were collected, oocytes isolated, matured, and then fertilized or activated in vitro as described in detail before (Grazul-Bilska et al., 2003, 2006, 2008; Borowczyk et al., 2006). Briefly, cumulus oocyte complexes (COC) were isolated from follicles $\geq$3 mmm; the average number of collected COC/sheep was 19.3±1.6. For IVF and IVA procedures, oocytes (up to 30 oocytes/0.5 ml in 4-well Nunc culture dish) were incubated overnight in maturation media (TCM199; Sigma, St. Louis, MO, USA) supplemented with 10% fetal bovine serum (FBS), ovine FSH [5 µg/mL; oFSH-RP-1; NIAMDD-NIH, Bethesda, MD, USA], ovine LH [5 µg/mL; oLH-26; NIADDK-NIH], estradiol -17β [1 µg/mL; Sigma], glutamine [2 mM; Sigma], sodium pyruvate [0.25 mM; Sigma], epidermal growth factor [10 ng/mL; Sigma,] and penicillin/streptomycin [100 units/mL penicillin and 100 µg/mL streptomycin; Gibco, Grand Island, NY, USA]). After denuding oocytes from cumulus cells, half of oocytes from each sheep was used for IVF and another half for IVA. For IVF, oocytes were cultured in fertilization media in the presence of capacitated frozen-thawed sperm (0.5-1 x 10^6 sperm/ml) for 24 h followed by incubation in culture media till embryo transfer (ET; see below). For IVA, oocytes were incubated for 5 min in TCM199 media containing 2% FBS and ionomycin (2.5 µM; Sigma) followed by 3 h incubation with 6-dimethylaminopurine (DMAP; 2 mM; Sigma). In vitro activated oocytes were then transferred to culture media and incubated till ET (see below).

For NAT-ET group, on day 5 post-mating, embryos were flushed, evaluated under the stereomicroscope, and then transferred to synchronized recipients (3 embryos/recipient). For IVF and IVA groups, in vitro generated embryos were transferred on day 5 after fertilization or activation to synchronized recipient ewes (3 embryos/recipient) as described by Grazul-Bilska et al. (2003, 2006). On day 22 after mating, fertilization or activation utero-placental tissues were collected. For histology/immunohistochemistry, specimen pins were inserted completely through the uterus and FM at the level of the external intercornual bifurcation to maintain specimen morphology; cross sections of the entire gravid uterus (approximately 0.5-cm thick) were obtained using a Stadie-Riggs microtome knife followed by immersion in formalin or Carnoy's solution and embedding in paraffin. Fetuses were separated from fetal membranes and crown-rump length of each fetus was measured. We choose day 22 for tissue collection, since in our previous experiments, we have demonstrated that on days 20-22, the major changes in cell proliferation, vascularization and expression of angiogenic factors appeared in fetal and maternal placenta for pregnancies achieved through natural breeding (Grazul-Bilska et al., 2010, 2011), and also placentation is already initiated (Igwebuike, 2009).

Immunohistochemistry. Immunohistochemical procedures were described previously (Grazul-Bilska et al. 2010, 2011). Briefly, paraffin-embedded uterine tissues containing FM were sectioned at 4 µm and mounted onto slides. Sections were rinsed several times in PBS containing Triton-X100 (0.3%, v/v) and then were treated for 20 min with blocking buffer [PBS containing normal horse serum (2%, vol/vol)] followed by incubation with specific primary antibody for Ki67 (a marker of proliferating cells; 1:500; mouse monoclonal; Vector Laboratories, Burlingame, CA, USA) overnight at 4˚ C. Primary antibodies were detected by using secondary anti-mouse antibody coupled to peroxidase (ImPress Kit; Vector Laboratories). Then, the sections stained with Ki67 were counterstained with nuclear fast red (Sigma, St. Lois, MO, USA). Control sections were incubated with normal mouse IgG (4 μg/mL) in place of primary antibody.

Image analysis. For each tissue section, images were taken at 400x magnification, using an Eclipse E600 Nikon microscope and digital camera for 5-10 randomly chosen fields (0.025 mm^2 per field) from maternal placenta containing caruncle (CAR), inter-CAR (ICAR) and fetal placenta (FM), separately. To determine labeling index (LI) in maternal and fetal placenta an image analysis system (Image-Pro Plus, Media Cybernetics, Inc., Bethesda , MD, USA) was used as described previously (Grazul-Bilska et al. 2010, 2011). The LI was calculated as the percentage (%) of proliferating Ki67-positive cells out of the total number of cells in CAR, ICAR and FM tissue area.

Statistical Analysis. Data were analyzed using the general linear models (GLM) procedure of SAS and presented as means ± SEM with the main effect of pregnancy type (SAS Institute 2010). When the F-test was significant ($P<0.05$), differences between specific means were evaluated by using the least significant differences test (Kirk 1982).

RESULTS

The length of the fetus was the greatest ($P<0.0001$) in NAT group, less in NAT-ET, and least in IVF and IVA groups (Fig. 1A). In IVF and IVF groups, length of fetus was approximately 2-fold less than in NAT group (Fig. 1A).

Marker of proliferating cells, Ki67 protein was detected in nuclei of fetal and maternal placenta in all groups (Fig. 2). Labeling index was greater ($P<0.001$) in fetal placenta than in maternal placenta in all groups. In NAT group, LI was 24.5±2.9% and 3.5±0.3% in fetal and maternal placenta, respectively. Labeling index in CAR and ICAR of maternal placenta was similar; therefore data were combined for these two uterine compartments within each group. In maternal placenta, LI was less ($P<0.001$) in NAT-ET group and least in IVF and IVA groups compared to NAT, and in fetal placenta, LI was less ($P<0.001$) in NAT-ET and IVF groups and least in IVA group compared to NAT (Fig. 1B).

DISCUSSION

Application of ART may have no effects or some negative effects on placental and fetal development or pregnancy outcome in several species including humans, mice, sheep or cows. Compared to in vivo natural fertilization, IVF has been demonstrated to affect embryonic and fetal development, placentation and implantation, placental function and growth, duration of gestation, embryonic loss/survival, appearance of some pathologies, birth weight and others in several species (Barnes, 2000; Bertolini et al., 2002; Cai et al., 2006; Farin et al., 2006; Grazul-

Bilska et al., 2006; Romundstad et al., 2006; Allen et al., 2008; Collier et al., 2009; Delle Piane et al., 2010; Sellers Lopez et al., 2010; Esh-Broder et al., 2011; Tomic and Tomic, 2011).

In the present experiment, combination of induction of superovulation with natural breeding and ET (our NET-ET group) decreased fetal size by 15%, but application of IVF or IVA decreased fetal size by more than 50% during early pregnancy. For cows, shorter crown-rump length of fetuses created in vitro compared to fetuses created in vivo has been reported for early pregnancy (Bertolini et al., 2002). On the other hand, Farin et al. (2006) reported that length of bovine embryos produced in vitro almost doubled compared to embryos produced in vivo during early pregnancy; this could lead to large offspring syndrome. Thus, conditions created during superovulation combined with natural breeding and embryo transfer, in vitro fertilization or activation and early embryonic development may have negative effects on fetal growth during early pregnancy.

Cell proliferation in maternal and fetal placenta was decreased by application of ART in our study. Although the LI was approximately 10-fold lower in maternal than fetal placenta, the pattern of changes of LI was very similar in both placental compartments. Placental cell proliferation in pregnancies affected/compromised by application of ART or environmental factors (e.g., maternal nutrition, age or others) has received limited attention. However, decreased LI was observed in placenta of adolescent overnourished ewes, which were also characterized by impaired fetal and placental growth during mid to late gestation (Lea et al., 2005; Redmer et al., 2009). In pregnancy compromised by diabetes, both increased and decreased cell proliferation was observed in placenta in rats (Caluwaerts et al., 2000; Zorn et al., 2011). For diabetic mice, decreased cell proliferation in myometrium during early pregnancy was reported (Favaro et al., 2010). On the other hand, cell proliferation was similar in diabetic and healthy human term placenta (Burleigh et al., 2004). Furthermore, several studies demonstrated high cell proliferation rates in utero-placental tissues during early pregnancy achieved through natural fertilization in humans (Korgum et al., 2006; Kar et al., 2007), sheep (Zheng et al., 1996), cows (Boos et al., 2006; Facciotti et al., 2009), rats (Correia-de-Silva et al., 2004) and monkeys (Blankenship and King, 1994; Wei et al., 2005). Thus, high cell proliferation observed in maternal and fetal placenta in natural pregnancy is decreased during early pregnancy after ART application or compromised by other factors in several species. This likely contributes to impaired fetal and placental growth, and offspring outcome.

In the present study, we have evaluated fetal and maternal placental growth on day 22 of pregnancy only. Therefore, we cannot exclude that the differences in placental growth among investigated pregnancy types may decrease due to possible compensatory mechanisms, or alternatively may increase as pregnancy progresses. Thus, future studies should evaluate placental growth during later stages of pregnancy.

Tissue growth including cell proliferation is regulated by growth and other regulatory factors in placenta and other tissues (Zheng et al., 1996; Reynolds et al., 2006, 2010; Grazul-Bilska et al., 2010, 2011). Since we have observed reduced expression of several growth factors known to regulate placental function including fibroblast growth factor (FGF) 2, FGF receptor, placental growth factor and others in maternal or fetal placenta after application of ART during early pregnancy (Johnson et al., 2011), we hypothesize that application of ART decreased expression of regulatory factors which in turn contributed to reduced cellular proliferation and fetal size. However, the role and expression of factors controlling tissue growth and cell proliferation in placental function requires further investigation.

In summary, application of ART techniques decreased fetal size and cell proliferation in fetal and maternal placenta during early pregnancy. Thus, ART may have specific effects on growth and function of ovine maternal and fetal placenta and fetal tissues through regulation of cell proliferation and tissue growth, and likely other mechanisms. These data provide a foundation for determining the expression of specific factors regulating placental and embryonic tissue growth in pregnancies after ART application. In addition, these data will help us to better understand placental regulatory mechanisms in compromised pregnancies, and to identify strategies for rescuing such pregnancies.

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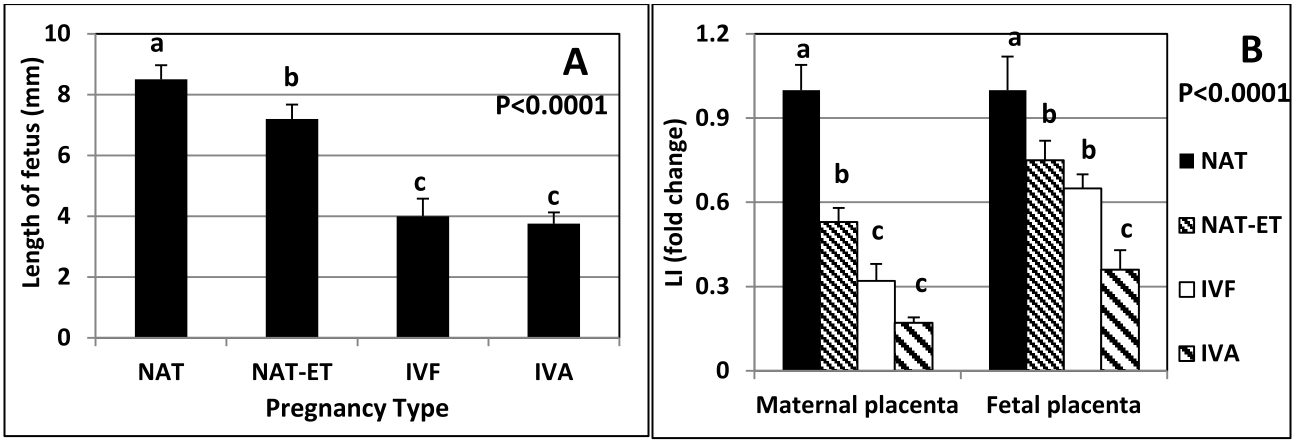

Figure. 1. The length of fetus (A) and labeling index (LI) in maternal and fetal placenta (B) in NAT, NAT-ET, IVF and IVA groups. Values ± SEM with different superscripts (a, b, c) differ within measurement. For LI, data are expressed as fold change compared to NAT control arbitrary set as 1. In NAT group, LI was and 3.5±0.3% and 24.5±2.9% in maternal and fetal placenta, respectively.

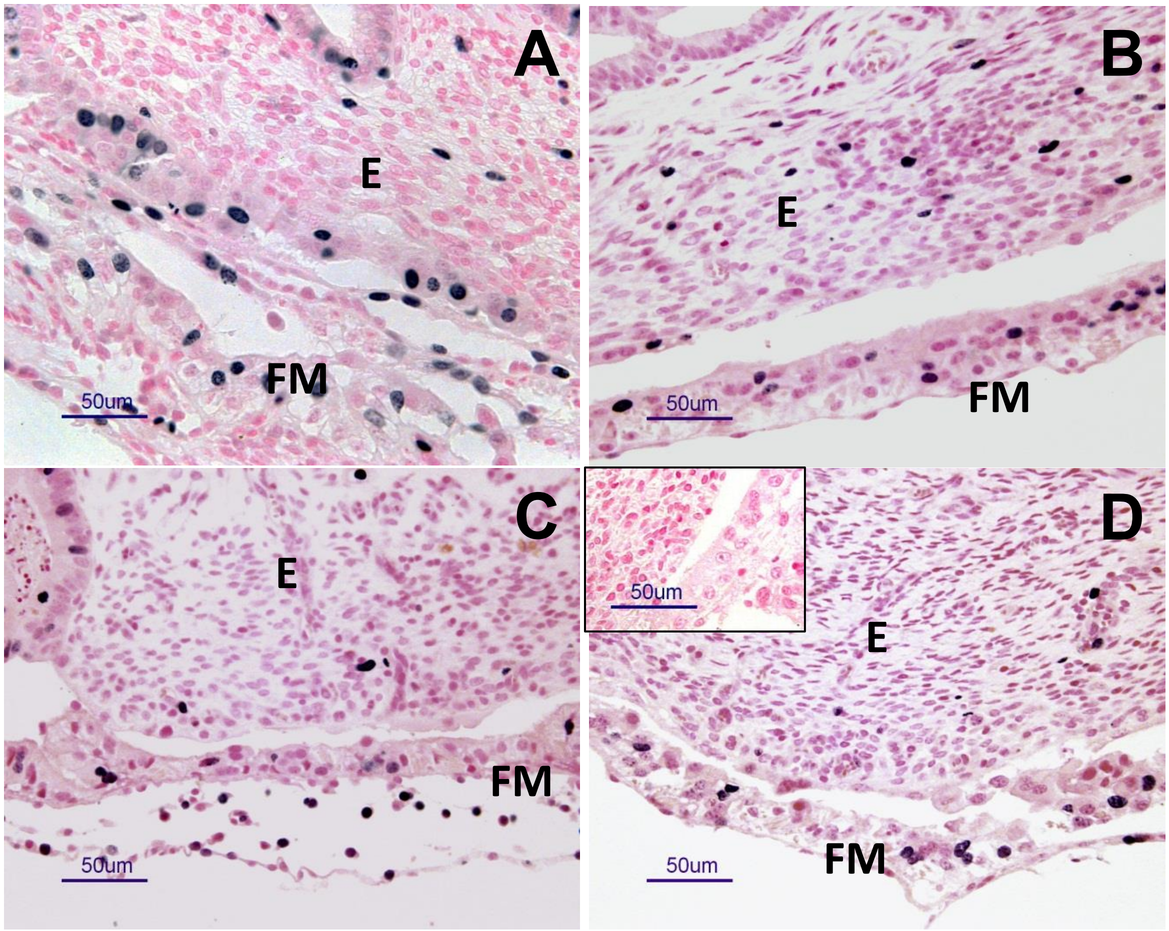

Figure. 2. Representative photomicrographs of immunohistochemical staining for Ki67 in maternal and fetal placenta in in NAT (A), NAT-ET (B), IVF (C) and IVA (D) groups. Dark color represents positive staining and pink color (nuclear fast red staining) indicates unlabeled cell nuclei. Note nuclear staining of Ki-67 in fetal placenta (FM) and endometrium (E, maternal placenta). In inset (D), note a lack of positive staining in the control sections in which mouse IgG was used in place of the primary antibody

Impacts of supplemental arginine on reproductive performance in sheep

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The objective of this study was to determine the effects oral and injectable supplementation of arginine two weeks post breeding on ewe reproductive performance and lamb growth. Prenatal lamb loss accounts for a large portion of economic loss in the sheep industry. Sheep producers could benefit from a supplementation protocol that recovered these losses.

INTRODUCTION

Reproductive performance is the largest determinant of income in livestock production. In the U.S. sheep industry, embryonic and fetal death can account for 25-50% of the total number of ovulations (Knights, et al., 2003; Dixon et al., 2007). The majority of embryonic loss occurs before d 18 of gestation (Hulet et al., 1956; Moore et al., 1960; Quinlivan, 1966). However, the loss of individual embryos can occur without a complete loss of pregnancy, such as in the case of multiple pregnancies (Rhind et al., 1980; Schrick and Inskeep, 1993). In sheep, it has been reported that 30% of fertilized ova are not represented by live births, resulting in frequent, but unrecognized economic loss (Knights et al., 2003; Bolet, 1986; Dixon et al., 2007). Furthermore, a small percentage of embryos are inherently non-viable (Wilmut et al., 1986), which suggests early embryonic loss is likely preventable in the ewe. Strategies to enhance prenatal growth and survival could clearly have a major economic impact in the sheep industry. Past research by NDSU has shown that supplemental arginine (**Arg**) can recover embryonic and/or fetal loss in fall lambing ewes synchronized to estrus with exogenous hormones (Saevre et al., 2011; Luther et al., 2009).

The amino acid L-arginine is a precursor for nitric oxide and important in the synthesis of polyamines and proteins, all of which are essential to proper development of the embryo and placenta. Past NDSU research has observed increased pregnancy rate in ewes treated with injectable L-arginine when compared to control ewes by 45% (Saevre et al., 2011; Luther et al., 2009). However, this previous research has always utilized an injectable Arg source, which is not readily adaptable to producer use. In order for producer acceptance of Arg supplementation to occur, a feed option must be found. It is reasonable to hypothesize from the previous studies that supplementation of rumen-protected arginine would have beneficial impacts on prenatal growth and survival for ruminant livestock.

The objective of this study was to determine the effects of injectable (Exp. 1) and oral (Exp. 2)

Arg supplementation provided two wk post breeding on reproductive performance of naturally stimulated fall lambing ewes.

PROCEDURES

All procedure were approved by the Animal Care and Use Committee of North Dakota State University. This study was conducted at the Hettinger Research Extension Center in Hettinger, ND.

Animals and Diets. Rambouillet ewes of a similar BW (142.6 ± 15.01 lbs.) were randomly assigned to one of six treatment groups: control (**CON**; n= 25), IV-alanine (**IVALA**; n=20), IV-arginine (**IVARG**; n=23), rumen-protected arginine (**RPARG**; n=20), soybean meal (**SBM**; n=23), fishmeal (**FM**; n=24). Ewes were exposed to 15 fertile ram lambs for 2 weeks before the trial start. During this time, ewes were fed one pound of corn/hd/d. Ewes were exposed to fishmeal at 12% of corn intake for 4 days during the 2 weeks pre-breeding to adapt them to the taste and smell of fishmeal. Ewes were fed 6 lb per day (as fed) a ration consisting of 25% alfalfa haylage and 75% grass hay. Ewes were exposed to mature rams one day before the start of the trial. Any ewes that were bred during the two weeks before the start of the project were removed from the trial. Ewes that received breeding marks 10 - 17 d post ram introduction were allocated to treatments. Thereafter, ewes were moved to a different pen and exposure to fertile rams for an additional 14 days. From d 0 (estrus) to d 14 (post estrus) ewes received their assigned treatment. In Exp. 1, all ewes received 1 lb of corn daily and injected with similar volumes of their treatment to provide 30 $mg\cdot kg^{-1}\cdot hd^{-1}\cdot d^{-1}$ Arg. Intravenous injections of arginine, alanine, and saline were administered daily to IVARG, IVALA, and CON ewes. In Exp. 2, all ewes received 1 lb/d of their respective treatments to provide 30 $mg\cdot kg^{-1}\cdot hd^{-1}\cdot d^{-1}$ Arg to the Arg supplemented treatments. Treatments were: RPARG (0.15 g/kg BW rumen protected product mixed with ground corn), SBM (25:75 soybean meal: corn), and FM (37.5:62.5 fishmeal: corn). The CON treatment form Exp. 1 served as the control treatment for Exp. 2. Blood samples were collected from 12 ewes per treatment group prior to administration of treatment every other day during 14-day trial treatment period. Blood samples were assayed for concentrations of progesterone. At lambing, birth weight, birth type, and sex were collected. Weaning weights were collected when the average age of lambs was 60 d.

Statistical Analysis. Pregnancy, prolificacy, and lambing rates were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Arginine treatment served as the fixed effect. The fixed effect of day was utilized in the REPEATED measures analysis for progesterone concentrations. The model included the fixed effects of dietary treatment, day, and treatment x day. Significance was determined at $P \leq 0.05$. To partition day effects and treatment × day interactions, LS Means were utilized ($P \leq 0.05$).

RESULTS

In Exp. 1, no differences were detected for pregnancy, prolificacy, and lambing rates among treatments (P = 0.95, 0.35, and 0.70, respectively; Table 1). Similary, in Exp. 2, no differences were detected for pregnancy, prolificacy, and lambing rates among treatments (P = 0.94, 0.61, and 0.80, respectively; Table 2). Additionally, there were no differences detected for progesterone concentrations for treatment or treatment by day interactions among treatments in Exp. 1 or 2 (P = 0.58 and 0.34, respectively; Figures 1 and 2, respectively). There was a day effect for both Exp. 1 and 2, but this observation was expected ($P < 0.0001$) due to the estrous cycle. Similar to gestational performance, there were no differences detected for birth weights in Exp. 1 and 2 among treatments (P = 0.57; P = 0.73, respectively; Tables 1 and 2). In Exp. 1, male lamb birth weights were significantly higher than female lambs (P = 0.014; data not shown). However, birth weights for Exp. 2 were similar for all treatments. Prolificacy had no effect on lamb birth weight in Exp. 1 (P = 0.07), but for Exp. 2 single born lambs were significantly heavier than twin lambs ($P < 0.0001$; data not shown). There were no differences detected for weaning weights in Exp. 1 and 2 among treatments (P = 0.53; P = 0.57, respectively; Tables 1 and 2). In Exp. 1, no differences were detected in weaning weights among the birth type (P = 0.17), however, in Exp. 2, single born lambs were significantly heavier than twin born lambs (P = 0.04; data not shown). In Exp. 1, male lamb weaning weights were significantly higher than female birth weights (P = 0.05; data not shown), but in Exp. 2 no differences were seen between male and female lamb weaning weight (P = 0.92).

DISCUSSION

In the present study, pregnancy, prolificacy, and lambing rates were not influenced through injectable or oral treatments. In contrast, research from this laboratory reported greater pregnancy rates in ewes supplemented with injectable Arg from d 0 through 14 post breeding and also ewes supplemented d 9 through 14 post breeding (Luther et al., 2009; Saevre et al., 2011). Moreover, pregnancy rates were much lower in the previous studies than in our study. Pregnancy rates were as follows: ARG (55%) vs. CON (60%), ARG (55%) vs. CON (30%), and IVARG (88%) vs. CON (88%) vs. RPARG (86%) (Luther et al., 2009; Saevre et al., 2011). We hypothesize that the differences in pregnancy rates between these projects could be due to a difference in reproductive synchronization models utilized as a comparison. Ewes in the previous two studies were synchronized artificially with a CIDR and an injection of PG-600, whereas the ewes in the present study were naturally synchronized using ram exposure.

Arginine is important for many biological functions, including the synthesis of nitric oxide (Gouge et. al., 1998; Manser et. al., 2004). Other studies have hypothesized that treatment with arginine at or slightly before the time of maternal recognition of pregnancy in the ewe may have enhanced the survival of the embryo during early embryogenesis through its role in polyamine and nitric oxide synthesis (Luther, et al., 2009). In the current study, however, increased pregnancy, prolificacy or lambing rates were not observed for arginine treated ewes.

As stated previously, arginine is important for the synthesis of nitric oxide, which is important for dilating blood vessels, therefore increasing tissue blood flow. Increases in ovarian blood flow or flow to the corpus luteum during early pregnancy could result in higher progesterone concentrations. This could result in a more ideal environment for early embryonic survival in arginine treated ewes. However, no differences in progesterone concentrations were observed between arginine treated ewes and the controls.

IMPLICATIONS

Although previous results imply that embryonic survival in sheep can be enhanced when supplemented with arginine, we did not detect any improvements in reproductive performance or lamb growth in ewes supplemented with either injectable or rumen-protected forms of arginine. We hypothesize that supplemented arginine might enhance reproductive performance in compromised models, such as the previous studies (chemical synchronization, etc.). However, further research is needed to develop this hypothesis.

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Table 1. Effects of daily injection of treatments[1] two weeks post breeding on pregnancy, prolificacy and lambing rate in sheep

Item	Control	IV-Alanine	IV-Arginine	SEM	*P*-value[2]
Pregnancy[3]	88	91	88	7.1	0.95
Prolificacy[4]	1.32	1.21	1.43	0.11	0.35
Lambing Rate[5]	1.16	1.10	1.25	0.13	0.70
Birth Weight	11.8	12	11.5	0.53	0.57
Weaning Weight	54.3	48.7	50.6	3.0	0.53

[1]Control, 7 mL/kg BW saline (n=25); IV-Alanine, 0.110 mL/kg of BW (n=20), IV-Arginine, 0.093 mL/kg of BW, (n=23).
[2]*P*-value for F test of the mean.
[3]Pregnant treated ewes that lambed to the first estrus.
[4]Lambing rate of ewes that lambed.
[5]Lambing rate of ewes treated.

Table 2. Effects of daily injection of treatments[1] two weeks post breeding on pregnancy, prolificacy and lambing rate in sheep

Item	Control	RPARG	FM	SBM	SE	*P*-value[2]
Pregnancy[3]	88	86	89	83	8	0.94
Prolificacy[4]	132	117	117	126	10	0.61
Lambing Rate[5]	1.16	1.00	1.04	1.04	0.12	0.80
Birth Weight	11.8	11.6	11.6	11.4	0.57	0.73
Weaning Weight	55.0	56.7	51.3	52.7	3.0	0.57

[1]Control, 7 mL/kg BW saline (n=25); RPARG, 0.15 g/kg BW (n=20); FM, 25:75 ration (FM:corn) (n=24); SBM, 37.5:62.5 ration (SBM:corn) (n=23).
[2]*P*-value for F test of the mean.
[3]Pregnant treated ewes that lambed to the first estrus.
[4]Lambing rate of ewes that lambed.
[5]Lambing rate of ewes treated.

Figure 1. Progesterone concentrations throughout the treatment period in arginine and alanine injected ewes. Data are means ± S.E.

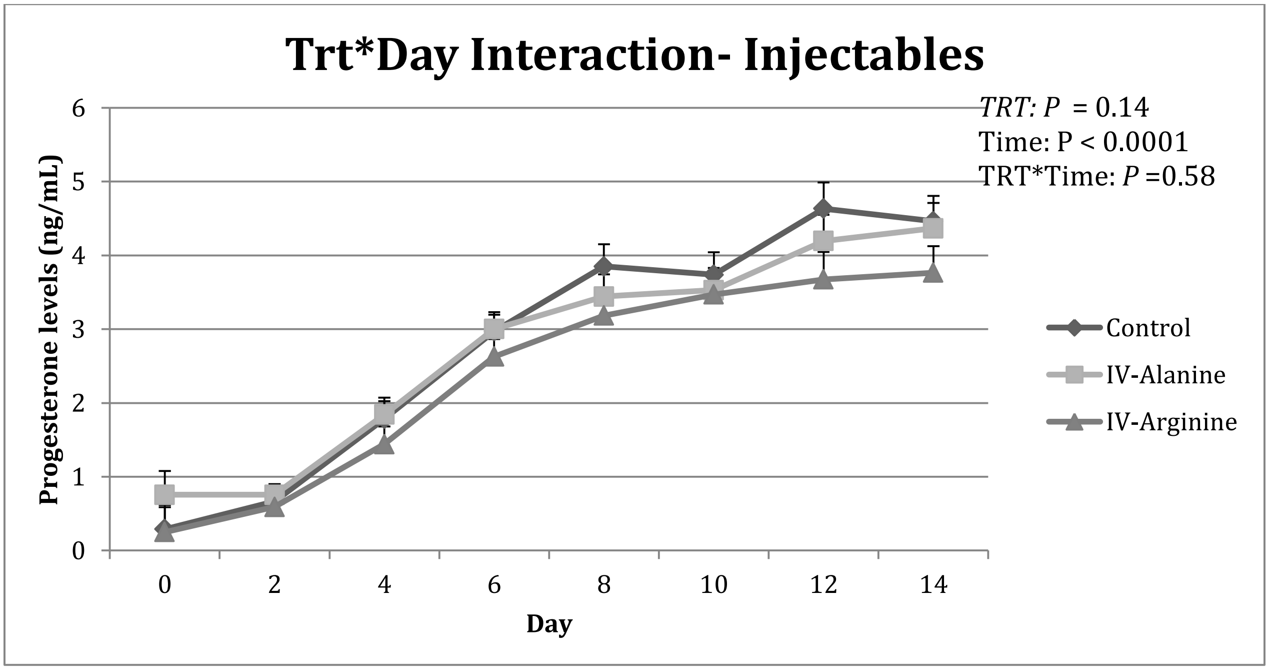
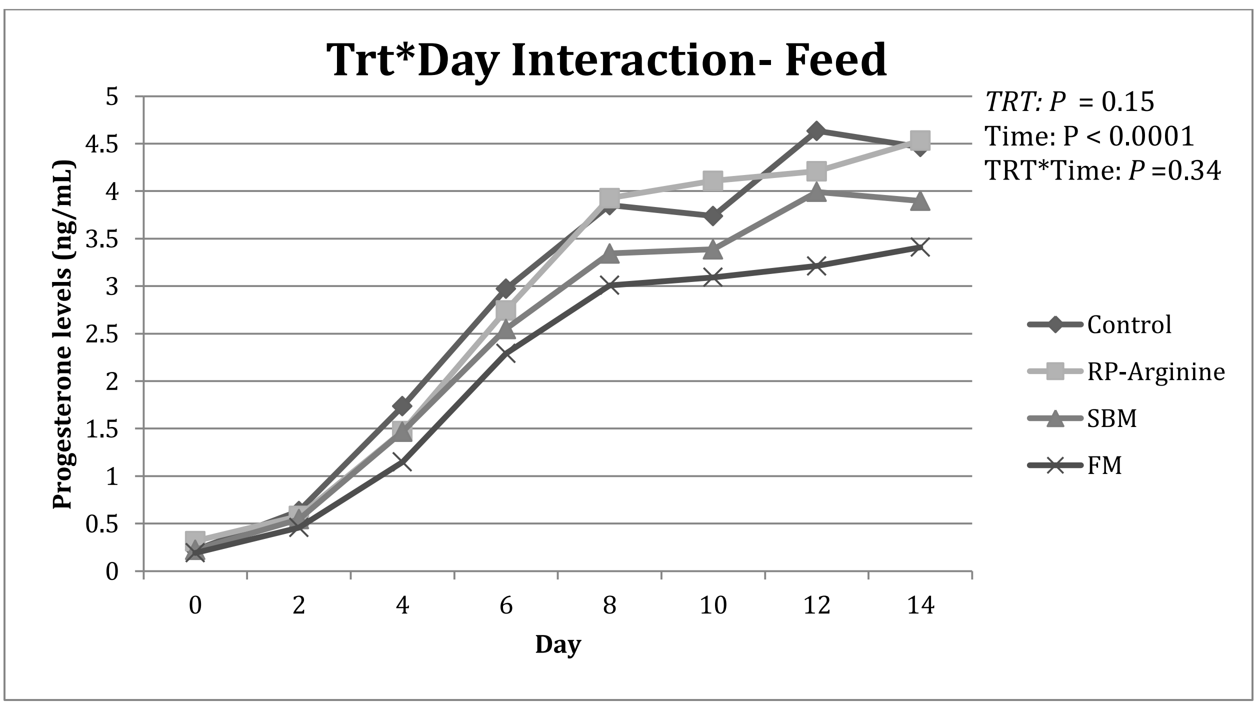


Figure 2. Progesterone concentrations throughout the treatment period in rumen-protected arginine (RPARG), fishmeal (FM), and soybean meal (SBM) treated ewes. Data are means ± S.E.



Efficacy of pregnancy specific protein B assay to predict pregnancy and pregnancy rate in sheep

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Our objective was to evaluate the effectiveness of the pregnancy specific protein B assay to predict early pregnancy and pregnancy rate in sheep. This test accurately detected flock pregnancy status after 30 days of pregnancy. Multiple pregnancies had greater PSPB concentrations in two of the four breeds.

INTRODUCTION

Most North Dakota sheep production scenarios require substantially more resources, such as feed, labor, and facilities during late gestation and lactation. Early identification of pregnancy and pregnancy rate in sheep provides managers several options to increase flock productivity. First, removal of non-pregnant ewes can increase available resources for pregnant ewes. Second, identification of pregnancy status of ewe lambs (9 months of age) allows producer to market ewe lambs as lamb, instead of waiting until after the lambing season, when ewe lambs will be older than 12 months and are more likely to be classified as mutton. Third, identification of pregnancy rate in sheep allows producer to target feed resources to ewes baring multiple lambs. Twin baring ewes require 30% more feed than singleton baring ewes. Finally, identification of early and late lambing ewes allows producer to target feed resources to ewes during period of greatest need. Late gestation singleton and twin baring ewes require 50 and 80% more feed, respectively, than ewes in early gestation.

Ultrasonic imaging is the most common method to determine pregnancy and pregnancy rate. This technique requires expensive equipment and a highly trained technician. Many states require this technique be conducted by a licensed veterinarian. Qualified technicians or veterinarians are not available to many sheep producers or costs associated with travel to remote locations are prohibitive. BioTracking, LLC developed a commercially available pregnancy-specific protein B (PSPB) test for pregnancy in cattle. The test was named BioPRYN®, with PRYN standing for “Pregnant Ruminant Yes No”. This technology was licensed by BioTracking from the University of Idaho and the assay was converted to an enzyme-linked immunosorbent assay (ELISA). The PSPB test was later developed for sheep and goats.

Our objectives for this study were to determine the earliest day of pregnancy that the BioPRYN test could accurately detect pregnancy status and pregnancy rate.

PROCEDURES

All experimental protocols were approved by the North Dakota State University Animal Care and Use Committee. This study consisted of two different experiments both held at the NDSU Sheep Unit in Fargo, ND.

In Exp. 1, Columbia and Hampshire ewes were exposed to intact rams equipped with marking harnesses on August 15th, 2011. Breeding marks were identified and recorded. On days 20, 25, 30, 40, and 60 post-breeding, blood samples were collected to determine PSPB concentrations. In Exp. 2, Dorset and Katahdin ewes were exposed to intact rams on September 27, 2011. Blood samples were taken from all ewes 7, 9, and 11 weeks post ram introduction. Lambing records were used to verify conception dates and lambing rates.

All blood samples were collected via jugular venipuncture into 10 mL serum tubes (BD Vacutainer Serum, Becton, Dickinson and Company, Franklin Lakes, NJ) and immediately placed on ice. Samples were centrifuged at 4˚C for 30 min at 1,500 x g and serum was transferred into plastic 2.0 mL microcentrifuge tubes and frozen at -20 ˚C until assayed. After all samples were collected, samples were shipped to BioTracking for analysis.

Only, 2 Columbia ewes and 1 Hampshire ewe gave birth to triplets. Two Katahdin ewes gave birth to singleton lambs. All five ewes were removed from the analysis because of limited number of ewes within lambing groups.

Pregnancy classification as determined by BioPRYN at different stages of pregnancy was analyzed using the PROC FREQ and CHI-SQUARE function of SAS (SAS Inst., Inc., Cary, NC). Repeated measures of the MIXED procedure of SAS were used to analyze serum concentrations of PSPB. Breed, day of pregnancy, and their interaction were significant in the model; therefore, breed and day of pregnancy sorted and analyzed independently. Data are presented as least squares means and treatment differences were considered significant at $P \leq 0.05$.

RESULTS

To determine the earliest that the BioPRYN test could detect pregnancy, samples were classified into three subcategories: less than 25, between 25 and 30, and over 30 days of pregnancy. There was a significant ($P < 0.01$) interaction between day of pregnancy tested and classification of pregnancy via BioPRYN testing. The test accurately detected pregnancy in 2, 83, and 98% of pregnant ewes when tested less than 25, between 25 and 30, or greater than 30 days of pregnancy, respectively (Table 1).

Concentration of PSPB are presented for Columbia ewes that lambed to singleton and twin pregnancies (n = 14 and 7, respectively; Table 2). Number of lambs born did not have an effect on PSPB concentrations on days 20 and 60 post breeding ($P \geq 0.27$) in Columbia ewes. On days 25, 30, and 40 post breeding, twin pregnancies had greater ($P \leq 0.05$) PSPB concentrations than singleton pregnancies.

Concentration of PSPB are presented for Hampshire ewes that lambed to singleton and twin pregnancies (n = 11 and 7, respectively; Table 3). Number of lambs born did not have an effect on PSPB concentrations on days 20, 25, 30, 40, and 60 post breeding ($P \geq 0.06$) in Hampshire ewes.

Concentration of PSPB taken 49, 53, and 67 days post ram introduction to Dorset ewes that lambed to singleton, twin, and triplet pregnancies (n = 21, 37, and 5, respectively; Table 4). Actual days of pregnancy for the blood samples were back calculated from the lambing date. The average actual days of pregnancy were 40, 54, and 68 ± 7.5 for the three respective sampling dates. Number of lambs born did not have an effect on PSPB concentrations taken 49 days post ram introduction ($P = 0.11$) in Dorset ewes. Twin pregnancies had greater ($P \leq 0.01$) PSPB concentrations than singleton pregnancies on days 53 and 67 post ram introduction. Triplet pregnancies were not different ($P \geq 0.13$) from twin or singleton pregnancies on days 53 and 67 post ram introduction.

Concentration of PSPB taken 49, 53, and 67 days post ram introduction to Katahdin ewes that lambed to twin and triplet pregnancies (n = 13 and 6, respectively; Table 5). Actual days of pregnancy for the blood samples were back calculated from the lambing date. The average actual days of pregnancy were 37, 51, and 65 ± 8.1 for the three respective sampling dates. Number of lambs born did not have an effect on PSPB concentrations taken 49 days post ram introduction ($P \geq 0.06$) in Katahdin ewes.

DISCUSSION

Our first objective was to determine when the assay could accurately detect pregnancy in sheep. Although pregnancy was detected as early as day 20 in one ewe, 72% of pregnant ewes were falsely determined to be open when the test was conducted before 25 days of pregnancy. Testing between day 25 and 30 of pregnancy accurately determined 83% of pregnancies; however, the remaining ewes were determined to be open or required additional testing. Testing for PSPB after 30 days of pregnancy accurately identified 98% of pregnant ewes. One ewe tested open at 30 days of pregnancy; however, the next test identified the ewe as pregnant. Although this study was not designed to identify false positives, we did not have any open ewes that were determined to be pregnant by the PSPB test. There were some ewes that tested pregnant on initial tests but later testing identified the ewe to be open. We hypothesize that this was a result of failed pregnancies.

In agreement with previous research (Willard et al., 1995), breed and age of pregnancy were strongly correlated with PSPB concentrations. These contributing factors make it difficult to randomly take a sample from ewes that have been exposed to rams and determine pregnancy rate. Concentrations of PSPB were not correlated to litter size in the Hampshire and Katahdin breeds; whereas, concentration of PSPB and litter size were correlated in the Columbia and Dorset breed. There may be opportunity for sheep producer of this breed to sort into pregnancy groups by PSPB concentration; however, exact date of breeding must be known. Unfortunately, triplet baring ewes from both the Dorset and Katahdin breed did not express greater PSPB concentration than twin baring ewes.

Although, PSPB testing cannot definitely identify pregnancy rate, there may be opportunity for sheep producers to improve efficiency through this test. First, identification of pregnancy beyond 60 days of gestation was 100% accurate; therefore, ewes that failed to become pregnant or lost a pregnancy can be identified and removed from the flock. Second, individual ewe nutrition and management requirements increase as pregnancy progresses and if multiple pregnancies are present. Similarly, within a breeding group PSPB concentration were higher in ewes that possessed the oldest pregnancies or multiple pregnancies. Therefore, sorting a group of ewe by PSPB concentration would allow for producers to improve efficiency of feed, labor and facility resources.

IMPLICATIONS

The PSPB test was very effective at detecting pregnancies beyond 30 days and it is very likely to be as good as or better than most ultrasound technicians. Although PSPB concentrations were able to differentiate between single and multiple pregnancies, it was not consistent between breeds and age of pregnancy must be known. Skilled ultrasound technicians would likely be more accurate at detection of pregnancy rate than the PSPB test.

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Table 1. Number and percent of pregnant ewes classified as open, recheck or pregnant by PSPB test at different days of pregnancy in Exp. 1 and 2

	BioPRYN Classification[1]			
Days of Pregnancy	Open	Recheck	Pregnant	*P*-Value
< 25 days	31(72)	11(26)	1(2)	<0.01
25 – 30 days	2(3)	11(14)	67(83)	<0.01
≥ 30 days	1(0.3)	7(2)	299(98)	<0.01

[1]BioPRYN classification are open (less than 15 ng/mL), retest (15 to 30 ng/mL), or pregnant (greater than 30 ng/mL).

Table 2. Serum pregnancy specific protein B (PSPB) concentrations in pregnant Columbia ewes[1]

	Number of Lambs Born				
Day of Pregnancy	Singleton	Twin	Triplet	SE	*P*-Value
20	11.6	14.5	.	1.9	0.24
25	33.1[a]	46.2[b]	.	5.0	0.05
30	59.7[a]	80.3[b]	.	6.1	<0.01
40	71.8[a]	90.8[b]	.	4.9	<0.01
60	114.2	125.5	.	10.5	0.13

[1] n = 14 and 7 for singleton and twin pregnancies, respectively.

Table 3. Serum pregnancy specific protein B (PSPB) concentrations in pregnant Hampshire ewes

	Number of Lambs Born[1]				
Day of Pregnancy	Singleton	Twin	Triplet	SE	*P*-Value
20	14.1	12.7	.	3.4	0.76

25	34.5	36.1	.	5.1	0.82
30	56.3	52.7	.	8.2	0.74
40	55.9	69.5	.	5.6	0.06
60	72.9	86.2	.	11.8	0.38

[1] n = 11 and 7 for singleton and twin pregnancies, respectively.

Table 4. Serum pregnancy specific protein B (PSPB) concentrations in pregnant Dorset ewes

	Number of Lambs Born[1]				
Days after Ram Introduction[2]	Singleton	Twin	Triplet	SE	*P*-Value
49	64.4[a]	79.2[b]	69.9[ab]	11.3	0.11
53	77.4[a]	97.5[b]	93.2[ab]	9.3	<0.01
67	79.7[a]	98.4[b]	89.1[ab]	9.4	<0.02

[1] n = 21, 37, and 5 for singleton, twin, and triplet pregnancies, respectively.
[2]The average days of pregnancy were 40, 54, and 68 ± 8.1 for the three respective sampling dates.

Table 5. Serum pregnancy specific protein B (PSPB) concentrations in pregnant Katahdin ewes

	Number of Lambs Born[1]				
Days after Ram Introduction[2]	Singleton	Twin	Triplet	SE	*P*-Value
49	.	66.4	74	6.3	0.35
53	.	67.5	84	9.3	0.17
67	.	65.7	77.7	7.8	0.22

[1] n = 13 and 6 for twin triplet pregnancies, respectively.
[2]The average days of pregnancy were 37, 51, and 65 ± 8.1 for the three respective sampling dates.

Effects of maternal metabolizable protein supplementation during the last 50 days of gestation on ewe performance and offspring performance from birth to weaning[1]

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The objectives of this trial were to determine the effects of maternal metabolizable protein supplementation during the last 50 days of gestation on ewe performance and offspring performance. Results indicate dam performance can be positively impacted by supplementing MP at or above requirements through maintaining dam BW and BCS, buy may have marginal effects on lamb performance from birth through weaning.

INTRODUCTION

Crude protein supplementation not only allows dams to maintain BW and BCS, but appears to improve offspring performance (Stalker et al., 2006; Larson et al., 2009). Crude protein supplementation to the dam is just one method of improving livestock performance during gestation. Metabolizable protein has been defined as the protein and amino acids that are digested and absorbed post-ruminally (Burroughs et al., 1975). Since MP is the protein directly available to the dam, it may be an indicator of how protein intake during gestation will ultimately affect offspring performance between birth and weaning. However, there has been minimal research conducted on the effects of MP intake during late gestation in sheep on offspring performance.

We hypothesized that the greater proportion of the diet that is composed of MP would yield improved offspring growth by potentially increasing nutrient transfer by the placenta or by increased nutrients within the milk. Therefore, the objectives were to evaluate isocaloric diets with increasing levels of MP during late gestation on ewe performance and offspring growth.

PROCEDURES

All procedures were approved by the NDSU Animal Care and Use Committee. This study was conducted at the Hettinger Research Extension Center in Hettinger, ND.

Ewes. On d 99 and 100 of gestation, in two consecutive years, ewes were weighed and body condition scored. On d 100 ± 8 (SD) of gestation, using the average of the initial weights (d 99 and 100 of gestation), ewes were stratified by BW, BCS, age, and expected lambing date to one of three isocaloric dietary treatments (Table 2; n = 7): **100MP1**: 100% of the MP requirements on a DM basis during the last 4 weeks of gestation of a ewe carrying twins (NRC, 2007);

60MP1: 60% of 100MP1; and **80MP1**: 80% of 100MP. Isocaloric dietary treatments (Table 2; n = 4) in year 2 were: **60MP2**: 60% of MP requirements; **100MP2**: 100% of the MP requirements; and **140MP2**: 140% of MP requirements on a DM basis of a ewe carrying twins during the last 4 weeks gestation (NRC, 2007). Once ewes had lambed, the ewes and lambs were intermingled between dietary treatments where they were maintained on a lactation ration (Table 1).

Lambs. In both years, lambs were weighed and tagged within 24 h of birth; sex, lambing assistance, and lamb vigor were also recorded. Lambs were then moved with the ewes to grouping pens and had full-access to creep pellet and water prior to weaning. At 14 days of age and at weaning all lambs were vaccinated for tetanus and *Clostridium Perfringens* types C and D (CD-T; Bar Vac CD-T, Boehringer Ingelhein, Ridgefield, CT), tails were docked, and ram lambs were castrated. Lambs were weaned at 69 ± 5 d (SD) of age in year 1 and at 61 ± 12 (SD) d of age in year 2 and weighed.

Statistical analysis. Ewe performance and lamb performance were analyzed utilizing the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). When a significant *F*-test was observed ($P \leq 0.15$), pre-planned comparisons of linear and quadratic contrasts were utilized to partition treatment effects. Significance was set at $P \leq 0.05$ and tendencies at $P \leq 0.10$.

RESULTS

Year 1

Ewes. Ewe weight change at lambing, change in BCS during gestation, gestation length, and lamb birth weight per unit initial or final ewe BW were not affected ($P \geq 0.22$; Table 3) by maternal dietary treatment. As MP increased in the diet, there was a linear ($P = 0.01$; Table 3) increase in change in BW during gestation. At lambing, ewe BW ($P = 0.02$) and BCS ($P = 0.01$) increased linearly as MP in the diet increased. There was a linear ($P < 0.001$) reduction in the percentage of BW loss from d 100 of gestation to immediately postpartum as MP increased in the diet. There was a linear increase in BCS loss as MP was reduced in the diet from d 100 ($P = 0.01$; Table 3) and 142 ($P = 0.05$) of gestation to immediately postpartum.

Lambs. There was no effect ($P = 0.30$; Table 3) of maternal dietary treatment on lamb birth weight. There tended to be a linear increase ($P \geq 0.08$) in weaning BW and ADG from birth to weaning as MP intake increased in the diet.

Year 2

Ewes. There were no significant effects ($P \geq 0.35$; Table 4) of maternal dietary treatment on ewe weight change from d 142 to lambing, change in BCS during gestation, change in BCS from d 100 and 142 to lambing, or BCS at lambing. As MP increased in the diet, there was a linear ($P = 0.01$) increase in change in BW. There was a linear ($P < 0.001$) reduction in percent BW loss from d 100 of gestation to immediately postpartum as MP increased in the diet. At lambing, ewe BW increased ($P = 0.02$) linearly as MP in the diet increased.

Lambs. There were no effects ($P \geq 0.25$; Table 4) of maternal dietary treatment on lamb birth BW, weaning BW, age at weaning, percent BW growth from birth to weaning, and ADG from birth to weaning.

DISCUSSION

Previous research has indicated that supplementation of protein during late gestation improves dam BW gain and BCS and restriction of protein results in reductions of dam BW and BCS (Stalker et al., 2006). Along with the current study, these studies suggest that increasing CP intake during late gestation enhances dam performance and minimizes the mobilization of dam body reserves to maintain fetal growth.

Similar to our results, Anthony et al. (1986) did not observe any effects on calf birth weight when dams were either fed low (81%) or high (141%) protein diets during late gestation (89 days prior to parturition). Amanlou et al. (2011) also observed no effects of maternal MP supplementation on lamb birth weight. Overall, our results suggest that birth weight may not be negatively impacted by maternal MP restriction.

Average daily gain of lambs from birth to weaning has also been positively affected by maternal nutrition during late gestation. Calves born to cows supplemented with CP during late gestation had increased ADG from birth to weaning compared with those calves born to unsupplemented cows (Stalker et al., 2006). In year 1, weaning BW tended to increase as MP increased in the diet, but weaning BW was not altered by maternal MP intake in year 2. The current results suggest that weaning weights may be reduced in lambs born to dams fed less than required MP, but feeding above MP requirements during late gestation may not improve weaning weights of lambs.

IMPLICATIONS

These results suggest that dam performance can be positively impacted by supplementing MP at or above requirements through maintaining dam BW and BCS. Restricting MP during late gestation may not negatively impact lamb birth weights, but may reduce weaning weights especially when ewes are below a BCS of 3. However, supplementing above MP requirements during late gestation will likely improve weaning weights. The results of the current study suggest that supplementing MP during late gestation may be a key asset to be utilized to improve dam performance from late gestation to weaning, but may have marginal effects on lamb growth from lambing to weaning.

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Table 1. Nutrient composition of fescue straw and lactation ration in years 1 and 2

	Fescue Straw[1]		
Item	Year 1	Year 2	Lactation Ration[2]
Diet, % DM	64.51	56.51	100.00
DM, %	83.05	77.61	64.37
NEm, Mcal/kg	2.22	2.12	—
CP, % of DM	3.04	3.07	11.52
MP, % of DM	1.95	1.97	—
NDF, % of DM	79.85	81.13	48.05
ADF, % of DM	48.97	51.10	27.16
Ash, % of DM	9.49	7.78	8.59

[1]Ewes were fed fescue straw in each year to limit metabolizable protein intake.
[2]Ewes were fed a common ration during lactation across all dietary treatments; 28.5% oats, 28.5% haylage, 42.9% chopped hay.

Table 2. Ingredient and nutrient composition of dietary supplements fed to ewes in year 1 and 2

	Year 1[1]			Year 2[2]		
Item	60MP1	80MP1	100MP1	60MP2	100MP2	140MP2
Ingredient, % DM						
Corn	18.50	15.00	5.00	30.00	19.00	—
DDGS[3]	7.00	20.00	30.00	4.00	24.00	43.00
Soyhulls	9.50	—	—	9.00	—	—
Trace mineral[4]	0.49	0.49	0.49	0.49	0.49	0.49
Nutrient composition						
DM, %	88.75	89.34	89.68	88.64	90.19	92.16
NEm, Mcal/kg	2.00	2.22	2.14	2.05	2.19	2.06
CP, % of DM	13.16	20.21	25.13	10.21	18.67	28.68
MP, % of DM	8.41	13.01	16.31	6.54	11.96	18.37
NDF, % of DM	31.03	30.73	39.79	29.64	31.40	45.34
ADF, % of DM	15.69	7.45	10.49	13.87	8.68	13.34
Ash, % of DM	3.22	3.48	4.55	3.53	3.80	5.13

[1]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP1: 60% of metabolizable protein of 100MP1; 80MP1: 80% of the metabolizable protein 100MP1; and 100MP1: 100% of the metabolizable protein requirement.

[2]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP2: 60% of metabolizable protein of 100MP2; 140MP2: 140% of the metabolizable protein of 100MP2; 100MP2: 100% of the metabolizable protein requirement.

[3]Dried distillers grains with solubles

[4]Trace mineral content: 16.0-17.0% Ca; 8.0% P; 21.0-23.0% Salt; 2.75% Mg; 3 ppm Co; 5 ppm Cu; 100 ppm I; 1,400 ppm Mn; 20 ppm Se; 3,000 ppm Zn; 113,500 IU/kg Vitamin A; 11,350 IU/kg Vitamin D; and 227 IU/kg Vitamin E.

Table 3. Effects of maternal metabolizable protein supplementation during the last 50 d of gestation on ewe and offspring performance from birth to weaning for year 1

	Dietary Treatment[1]					Orthogonal Contrasts[4]	
Item	60MP1	80MP1	100MP1	SEM[2]	*P* – value[3]	Linear	Quadratic
Initial BW, lb	139.8	142.0	142.4	2.36	0.71	0.43	0.79
BW at lambing,[5] lb	130.5	137.3	138.7	2.51	0.04	0.02	0.36
Weight change, lb							
Gestation	14.3	19.6	20.1	1.30	0.01	0.01	0.15
Lambing	-27.7	-24.8	-26.4	1.30	0.33	0.50	0.16
Percent BW change,[6] %	-10.65	-4.98	-4.98	1.02	<0.001	<0.001	0.02
Initial BCS	2.9	2.9	2.9	0.03	0.51	0.53	0.33
BCS at lambing[5]	2.7	2.7	2.9	0.06	0.02	0.01	0.45
BCS change							
Gestation	-0.02	0.02	0.02	0.04	0.68	0.44	0.65
Lambing							
d 100 to lambing[7]	-0.20	-0.17	0.02	0.05	0.02	0.01	0.24
d 142 to lambing[8]	-0.18	-0.20	-0.02	0.05	0.06	0.05	0.14
Lamb birth weight, lb	10.0	9.9	10.4	0.24	0.30	0.22	0.33
Lamb weaning BW, lb	38.7	43.0	42.2	1.46	0.07	0.08	0.14
Lamb ADG,[9] lb/d	0.40	0.46	0.44	0.01	0.07	0.10	0.10

[1]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP1: 60% of metabolizable protein of 100MP1; 80MP1: 80% of the metabolizable protein 100MP1; and 100MP1: 100% of the metabolizable protein requirement.
[2]Greatest SEM presented (n = 7).
[3]*P* -value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Ewe BW and BCS measured within 24 h after parturition.
[6]Percent BW change from initial BW (d 100 of gestation) to BW immediately postpartum.
[7]Change in ewe BCS from the initial BCS (d 100 of gestation) to the BCS immediately postpartum.
[8]Change in ewe BCS from the final BCS (d 142 of gestation) to the BCS immediately postpartum.
[9]ADG calculated: (weight at birth, kg – weight at weaning)/age at weaning.

Table 4. Effects of maternal metabolizable protein supplementation during the last 50 d of gestation on ewe performance and offspring performance from birth to weaning for year 2

	Dietary Treatment[1]					Orthogonal Contrasts[4]	
Item	60MP2	100MP2	140MP2	SEM[2]	*P* – value[3]	Linear	Quadratic
Initial BW, lb	148.7	148.6	148.4	3.55	1.00	0.95	0.97
BW at lambing,[5] lb	134.0	142.0	144.1	3.17	0.06	0.02	0.48
Weight change, lb							
Gestation	11.4	17.6	19.2	1.72	0.02	0.01	0.28
Lambing	-27.8	-25.0	-24.8	1.90	0.35	0.26	0.60
Percent BW change,[6] %	-11.62	-5.09	-4.04	1.44	<0.001	<0.001	0.12
Initial BCS	3.0	3.0	3.0	0.01	0.40	0.22	0.40
BCS at lambing[5]	2.9	3.0	3.0	0.04	0.93	0.74	0.88
BCS change							
Gestation	0.00	0.00	-0.02	0.01	0.40	0.22	0.49
Lambing							
d 100 to lambing[7]	-0.06	-0.04	-0.04	0.04	0.94	0.74	0.88
d 142 to lambing[8]	-0.06	-0.04	-0.02	0.04	0.81	0.51	0.96
Lamb birth weight, lb	10.2	10.6	10.2	0.24	0.45	0.92	0.22
Lamb weaning BW, lb	33.6	36.8	35.4	1.87	0.49	0.51	0.33
Lamb ADG,[9] lb/d	0.40	0.44	0.40	0.02	0.25	0.78	0.11

[1]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP2: 60% of metabolizable protein of 100MP2; 140MP1: 140% of the metabolizable protein 100MP2; and 100MP2: 100% of the metabolizable protein requirement.
[2]Greatest SEM presented (n = 4).
[3]*P* -value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Ewe BW and BCS measured within 24 h after parturition.
[6]Percent BW change from initial BW (d 100 of gestation) to BW immediately postpartum.
[7]Change in ewe BCS from the initial BCS (d 100 of gestation) to the BCS immediately postpartum.
[8]Change in ewe BCS from the final BCS (d 142 of gestation) to the BCS immediately postpartum.
[9]ADG calculated: (weight at birth, kg – weight at weaning)/age at weaning.

Effects of maternal metabolizable protein supplementation during the last 50 days of gestation on male and female offspring performance post-weaning[1]

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The objectives of this trial were to determine the effects of maternal metabolizable protein supplementation in ewes during the last 50 days of gestation on male and female offspring performance post-weaning. Results suggest restricting MP intake to 60% of requirements to ewes during late gestation may negatively impact F1 offspring growth and reproductive performance, beginning with F1 birth weights.

INTRODUCTION

Crude protein supplementation not only allows dams to maintain BW and BCS, but appears to improve offspring performance (Stalker et al., 2006; Larson et al., 2009). Crude protein supplementation to the dam is just one method of improving livestock performance during gestation. Metabolizable protein has been defined as the protein and amino acids that are digested and absorbed post-ruminally (Burroughs et al., 1975). Since MP is the protein directly available to the dam, it may be an indicator of how protein intake during gestation will ultimately affect offspring performance both pre- and post-weaning. However, there has been minimal research conducted on the effects of MP intake during late gestation in sheep on offspring performance.

We hypothesized that the greater proportion of the diet that is composed of MP would yield improved offspring growth by potentially increasing nutrient transfer by the placenta or by increased nutrients within the milk. Therefore, the objectives were to evaluate isocaloric diets with increasing levels of MP during late gestation on male and female offspring performance post-weaning.

PROCEDURES

All procedures were approved by the NDSU Animal Care and Use Committee. This study was conducted at the Hettinger Research Extension Center in Hettinger, ND.

Ewes. On d 100 ± 8 (SD) of gestation, using the average of the initial weights (d 99 and 100 of gestation), ewes were stratified by BW, BCS, age, and expected lambing date to one of three isocaloric dietary treatments (Table 2; n = 7): **100MP1**: 100% of the MP requirements on a DM basis during the last 4 weeks of gestation of a ewe carrying twins (NRC, 2007); **60MP1**: 60% of 100MP1; and **80MP1**: 80% of 100MP. Isocaloric dietary treatments (Table 2; n = 4) in year 2 were: **60MP2**: 60% of MP requirements; **100MP2**: 100% of the MP requirements; and **140MP2**: 140% of MP requirements on a DM basis of a ewe carrying twins during the last 4 weeks gestation (NRC, 2007). Once ewes had lambed, the ewes and lambs were intermingled between dietary treatments where they were maintained on a lactation ration (Table 1).

Lambs. In both years, lambs were weighed and tagged within 24 h of birth; sex, lambing assistance, and lamb vigor were also recorded. Lambs were then moved with the ewes to grouping pens and had full-access to creep pellet and water prior to weaning. At 14 days of age and at weaning all lambs were vaccinated for tetanus and *Clostridium Perfringens* types C and D (CD-T; Bar Vac CD-T, Boehringer Ingelhein, Ridgefield, CT), tails were docked, and ram lambs were castrated. Lambs were weaned at 69 ± 5 d (SD) of age in year 1 and at 61 ± 12 (SD) d of age in year 2 and weighed.

Feedlot. In year 1, at 89 ± 5 (SD) days of age and in year 2, at 102 ± 11 (SD) days of age, wether lambs were revaccinated for CD-T and placed in the feedlot. In both years, wethers were allotted by maternal dietary treatment and blocked by weight (heavy and light) into one of two pens per maternal dietary treatment. Wethers were fed approximately 85% whole, shelled corn and 15% commercial market lamb pellet diet (Table 3). The feedlot ration was balanced to meet or exceed CP and NE requirements of growing lambs (NRC, 2007). Wethers were fed a mixed diet ad libitum via bulk feeders. Lambs had continuous access to fresh water and shade. In year 1, wether lambs were shipped to the Iowa Lamb Corporation (Hawarden, IA) or the NDSU Meat Lab (Fargo, ND) for carcass measurements. In year 2, all wethers were shipped to Superior Farms (Denver, CO).

Ewe lambs. In both years, F1 lambs were fed a mixed diet ad libitum via bulk feeders (Table 3). In year 1, between 108 ± 10 (SD) and 236 ± 10 (SD) days of age, F1 growth performance was measured. Body weights were taken every 14 days throughout the 128 day period. Growth performance in year 2 was measured from 63 ± 13 (SD) day of age to 191 ± 20 (SD) days of age. Body weights were taken at the beginning (d 0) and at the end (d 128) of the 128 day period. F1 breeding began at 259 ± 10 (SD) days of age in year 1 and 256 ± 9 (SD) days of age in year 2. F1 were maintained in a single flock during the 51 day breeding period. Rambouillet rams (n = 10) were fitted with marking harnesses and were introduced to the flock. Breeding harness crayons were changed to a different color on d 18 and 35 days post-ram introduction. Rams were removed from the pen 51 days after the rams were introduced. In both years, pregnancy was confirmed via ultrasonography 45 days after the rams were removed. In both years, lambs of F1 dams (**F2**) were treated similarly as lambs from ewes discussed previously.

Statistical analysis. Feedlot performance, carcass characteristics, F1 performance, and F1 reproductive efficiency were analyzed utilizing the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). When a significant *F*-test was observed ($P \leq 0.15$), pre-planned comparisons of linear and quadratic contrasts were utilized to partition treatment effects. Significance was set at $P \leq 0.05$ and tendencies at $P \leq 0.10$.

RESULTS

Year 1

Wethers. There was no effect ($P \geq 0.33$; Table 4) of maternal dietary treatment on initial BW, final BW, ADG, G:F, or morbidity. There was a quadratic effect ($P = 0.04$) for days on feed, with the 80MP1 lambs being on feed longer than the 60MP1 and 100MP1 lambs. A quadratic effect ($P = 0.05$) was also observed for DMI, with the 80MP1 wethers consuming less feed than the 60MP1 and 100MP1 wethers. There was no effect ($P \geq 0.27$; Table 4) of maternal MP intake during late gestation on carcass measurements, except a linear tendency ($P = 0.06$) for flank streaking to increase in wethers as MP increased in the late gestation ewe diet.

Ewe lambs. Weaning BW and ADG from birth to weaning, weaning to the end of the 128 d growth period, birth to the end of the 128 d growth period, initial BW, final BW, and ADG during the 128 day growth period were not altered ($P \geq 0.22$; Table 5) due to maternal MP dietary treatment. There was a quadratic effect ($P = 0.003$) for F1 birth weight, with the F1 offspring from 80MP1 ewes having increased birth weights compared with F1 from 60MP1 and 100MP1 ewes. The total percentage of F1 lambing, F1 lambing in the third 17 days of the lambing period, lambing rate, or on birth weight of F2 was not different ($P \geq 0.22$; Table 5) due to maternal dietary treatment. However, a quadratic effect ($P = 0.02$) was observed for the percentage of F1 being marked for breeding during the first 17 day breeding cycle with F1 born to ewes fed 80MP1 being increased compared with F1 born to ewes fed 60MP1 and 100MP1. F1 lambing to the first 17 day breeding cycle was increased linearly ($P = 0.001$) as MP intake increased in the maternal diet during late gestation. The percentage of F1 lambing during the second 17 day breeding cycle decreased linearly ($P = 0.02$) as MP intake in the maternal diet increased during late gestation

Year 2

Wethers. In year 2, there was no effect ($P \geq 0.12$; Table 6) of maternal dietary treatment on initial BW, final BW, ADG, G:F, or morbidity. There was a linear increase ($P = 0.04$) in DMI as maternal MP increased from 60 to 140% of MP requirements. Carcass characteristics were not affected ($P \geq 0.40$; Table 6) by ewe MP intake during late gestation.

Ewe lambs. Average daily gain during the 128 day growth period, from birth to the end of the 128 day growth period, and F1 birth weights were not altered ($P \geq 0.17$; Table 7) by maternal MP treatment. However, there tended ($P = 0.09$) to be a quadratic effect on weaning weights, where F1 from 100MP2 ewes tended to be increased compared with F1 from 60MP2 and 140MP2 ewes. There was a quadratic effect ($P = 0.01$) for ADG from birth to weaning of F1 from ewes consuming 100% of MP requirements being increased compared with F1 from ewes fed 60 and 140% of MP requirements. There tended to be a quadratic effect ($P = 0.07$) for final BW at the end of the growth period, where F1 from 100MP2 ewes weighed more on d 128 of the growth period compared with F1 from 60MP2 and 140MP2 ewes. There was no effect ($P \geq 0.76$; Table 7) of maternal MP treatment on the total percentage of F1 lambing or the percentage of F1 lambing to the first, second 17 days of the lambing season, and lambing rate. There tended to be a quadratic effect ($P = 0.09$) for F1 from ewes fed 100MP2 having increased F1 breeding during the first 17 days of breeding compared with F1 from 60MP2 and 140MP2 ewes. F1 from 60MP2 and 100MP2 fed ewes gave birth to heavier ($P = 0.05$) lambs than F1 from 140MP2 fed ewes. Birth weights of F2 born to F1 were reduced linearly ($P = 0.04$) as grand-dam MP intake increased during late gestation.

DISCUSSION

Performance during the feedlot phase in the current study was not affected by maternal MP intake. Previously, Larson et al. (2009) observed no differences in steer ADG, DMI, or G:F due to maternal dietary CP supplementation. Additionally, Stalker et al. (2006) reported no differences in calf ADG, DMI, or G:F during the finishing phase due to maternal CP supplementation. Overall, the current results suggest that feedlot performance in sheep may not be altered by maternal MP intake during late gestation.

Similar to the current results, Stalker et al. (2006) did not observe any differences in steer carcass measurements due to maternal CP supplementation during late gestation on steer offspring. However, similar to year 1, Larson et al. (2009) observed increased marbling scores steers born to cows that were supplemented with CP during late gestation. The current results suggest that maternal MP intake in isocaloric diets may have little impact on carcass characteristics of wether offspring.

To our knowledge, there has been little research conducted evaluating the feeding of MP or CP during late gestation in ruminants on their effects of female offspring post-weaning. Martin et al. (2007) observed an increase in adjusted 205 d BW, prebreeding BW, and BW at pregnancy diagnosis in heifers born to cows that were supplemented with CP during late gestation. As our results suggest, restricting MP intake to 60% of requirements to ewes during late gestation may negatively impact F1 offspring growth and reproductive performance, beginning with F1 birth weights.

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Table 1. Nutrient composition of fescue straw and lactation ration in years 1 and 2

Item	Fescue Straw[1]		Lactation Ration[2]
	Year 1	Year 2	
Diet, % DM	64.51	56.51	100.00
DM, %	83.05	77.61	64.37
NEm, Mcal/kg	2.22	2.12	—
CP, % of DM	3.04	3.07	11.52
MP, % of DM	1.95	1.97	—
NDF, % of DM	79.85	81.13	48.05
ADF, % of DM	48.97	51.10	27.16
Ash, % of DM	9.49	7.78	8.59

[1]Ewes were fed fescue straw in each year to limit metabolizable protein intake.
[2]Ewes were fed a common ration during lactation across all dietary treatments; 28.5% oats, 28.5% haylage, 42.9% chopped hay.

Table 2. Ingredient and nutrient composition of dietary supplements fed to ewes in year 1 and 2

	Year 1[1]			Year 2[2]		
Item	60MP1	80MP1	100MP1	60MP2	100MP 2	140MP2
Ingredient, % DM						
Corn	18.50	15.00	5.00	30.00	19.00	—
DDGS[3]	7.00	20.00	30.00	4.00	24.00	43.00
Soyhulls	9.50	—	—	9.00	—	—
Trace mineral[4]	0.49	0.49	0.49	0.49	0.49	0.49
Nutrient composition						
DM, %	88.75	89.34	89.68	88.64	90.19	92.16
NEm, Mcal/kg	2.00	2.22	2.14	2.05	2.19	2.06
CP, % of DM	13.16	20.21	25.13	10.21	18.67	28.68
MP, % of DM	8.41	13.01	16.31	6.54	11.96	18.37
NDF, % of DM	31.03	30.73	39.79	29.64	31.40	45.34
ADF, % of DM	15.69	7.45	10.49	13.87	8.68	13.34
Ash, % of DM	3.22	3.48	4.55	3.53	3.80	5.13

[1]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP1: 60% of metabolizable protein of 100MP1; 80MP1: 80% of the metabolizable protein 100MP1; and 100MP1: 100% of the metabolizable protein requirement.
[2]Maternal diets (DM basis) were balanced for mature ewes baring twins during the last 4 weeks of gestation according to NRC (2007). Treatments: 60MP2: 60% of metabolizable protein of 100MP2; 140MP2: 140% of the metabolizable protein of 100MP2; 100MP2: 100% of the metabolizable protein requirement.
[3]Dried distillers grains with solubles
[4]Trace mineral content: 16.0-17.0% Ca; 8.0% P; 21.0-23.0% Salt; 2.75% Mg; 3 ppm Co; 5 ppm Cu; 100 ppm I; 1,400 ppm Mn; 20 ppm Se; 3,000 ppm Zn; 113,500 IU/kg Vitamin A; 11,350 IU/kg Vitamin D; and 227 IU/kg Vitamin E.

Table 3. Ingredient and nutrient composition of diets fed to feedlot wether lambs and ewe lambs in years 1 and 2

	Wethers		Ewe Lambs
Item	Year 1	Year 2	
Ingredient, %			
Oats	—	—	60.0
Whole corn	84.4	84.7	20.0
Market lamb pellet[1]	15.6	15.3	20.0
Nutrient composition			
DM, %	89.06	89.54	91.1
CP, % of DM	13.12	13.50	22.3
NDF, % of DM	13.48	22.93	23.8
ADF, % of DM	3.42	4.23	10.1
Ash, % of DM	4.59	5.52	10.5

[1]Commercial Market Lamb Pellet contained: 0.22 g/kg Chlortetracycline; 38.0% CP; 3.75-4.75% Ca; 0.6% P; 3.0-4.0% salt; 1.2 ppm Se; 52,863 IU/kg Vitamin A; 5,286 IU/kg Vitamin D; and 209 IU/kg Vitamin E.

Table 4. Effects of maternal metabolizable protein supplementation on feedlot performance and carcass characteristics of wethers in year 1

	Maternal Dietary Treatment[1]					Orthogonal Contrasts[4]	
Item	60MP1	80MP1	100MP1	SEM[2]	*P* – value[3]	Linear	Quadratic
Feedlot							
Initial BW, lb	64.4	62.2	65.7	4.59	0.85	0.82	0.60
Final BW, lb	153.9	150.8	146.6	3.51	0.33	0.14	0.89
Days on feed, d	127	133	123	3.8	0.10	0.38	0.04
ADG, lb/d	0.71	0.68	0.66	0.02	0.40	0.18	0.93
DMI, lb/lamb/d	3.31	3.17	3.28	0.04	0.13	0.84	0.05
G:F, lb gain:lb DMI	0.23	0.22	0.21	0.01	0.64	0.36	0.79
Morbidity,[5] %	6.4	20.5	20.2	9.1	0.33	0.22	0.43
Carcass characteristics							
HCW, lb	79.6	77.2	75.6	2.01	0.33	0.14	0.88
Dressing Percentage, %	51.8	51.2	51.4	0.44	0.53	0.53	0.38
LM area, in^2	2.74	2.74	2.73	0.08	0.95	0.76	0.94
Back fat thickness, in	0.28	0.31	0.28	0.02	0.27	0.43	0.14
Body wall thickness, in	1.10	1.06	1.06	0.04	0.72	0.42	0.92
Leg score[6]	12	12	12	0.2	0.84	0.61	0.74
Conformation score[6]	12	12	12	0.2	0.64	0.98	0.35
Flank streaking[7]	362	365	395	13.5	0.13	0.06	0.36
Quality grade[6]	12	12	12	0.1	0.38	0.17	0.98
Yield grade[8]	3.3	3.5	3.2	0.3	0.54	0.85	0.27
BCTRC,[9] %	44.79	44.94	48.56	2.01	0.34	0.19	0.48
WBSF,[10] lb	7.23	6.00	6.19	0.68	0.40	0.30	0.40

[1]Maternal dietary treatment: 60MP1: 60% of metabolizable protein of 100MP1; 80MP1: 80% of the metabolizable protein 100MP1; and 100MP1: 100% of the metabolizable protein requirement.
[2]Greatest SEM presented (n = 31 for 60MP1, n = 33 for 80MP1, and n = 24 for 100MP1).
[3]*P*-value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Percentage treated for illness during the feedlot phase.
[6]Leg score, conformation score, and quality grade: 1 = cull to 15 = high prime.
[7]Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.
[8]Yield grade = (back fat thickness × 10) + 0.4.
[9]Percent boneless, closely trimmed, retail cuts (% BCTRC) = [49.936 – (0.0848 × HCW, lb) – (4.376 × back fat thickness, in) – (3.53 × body wall thickness, in) + (2.456 × LM area, in^2)].
[10]Warner-Bratzler shear force.

Table 5. Effects of maternal metabolizable protein supplementation on ewe lamb growth and reproductive performance in year 1

	Maternal Dietary Treatment[1]					Orthogonal Contrasts[4]	
Item	60MP1	80MP1	100MP1	SEM[2]	*P* – value[3]	Linear	Quadratic
Birth weight, lb	9.9	11.5	10.8	0.31	0.002	0.05	0.003
Weaning BW, lb	40.1	43.9	42.3	2.16	0.41	0.41	0.28
ADG, lb/d							
Birth to weaning	0.42	0.49	0.46	0.029	0.37	0.36	0.26
Weaning to final[5]	0.60	0.60	0.60	0.015	0.78	0.55	0.74
Birth to final[5]	0.55	0.57	0.55	0.013	0.43	0.86	0.20
Growth period[6]							
Initial BW, lb	68.6	73.9	67.2	3.31	0.29	0.22	0.13
Final BW, lb	139.6	146.9	139.1	3.68	0.22	0.16	0.08
ADG, lb/d	0.55	0.57	0.57	0.018	0.80	0.61	0.55
Breeding in first 17 days,[7] %	50	84	67	9.3	0.03	0.15	0.02
Total lambing,[8] %	70	68	67	9.5	0.96	0.78	0.98
Lambing to first 17 days,[9] %	0	0	32	7.3	0.001	0.001	0.07
Lambing to second 17 days,[9] %	86	65	52	11.2	0.05	0.02	0.75
Lambing to third 17 days,[9] %	14	35	16	9.8	0.22	0.89	0.08
Lambing rate,[10]	0.73	0.80	0.81	0.12	0.88	0.64	0.83
Lamb birth weight, lb	10.6	10.6	10.4	0.44	0.85	0.64	0.78

[1]Maternal dietary treatment: 60MP1: 60% of metabolizable protein requirements; 80MP1: 80% of metabolizable protein requirements; and 100MP1: 100% of metabolizable protein requirements.
[2]Greatest SEM presented (n = 30 for 60MP1, n = 25 for 80MP1, and n = 36 for 100MP1).
[3]*P*-value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Weaning to final indicates the ADG from weaning to the final BW measured on d 128 of the 128 day growth period. Birth to final indicates the ADG from birth to the final BW measured on d 128 of the 128 day growth period.
[6]Growth period that was 128 days in length to measure growth performance of the ewe lambs.
[7]Percentage of ewe lambs per treatment having breeding marks in the first 17 days of the breeding season.
[8]Total percentage of ewe lambs lambing per ewe lamb exposed per maternal dietary treatment.
[9]Percentage of ewe lambs lambing that were bred during the first 17 days post-ram turnout, the second 17 days post-ram turnout, or the third 17 days post-ram turnout.
[10]Lambing rate: number of lambs born per ewe exposed to the rams.

Table 6. Effects of maternal metabolizable protein supplementation on feedlot performance and carcass characteristics of wethers in year 2

	Maternal Dietary Treatment[1]					Orthogonal Contrasts[3]	
Item	60MP2	100MP2	140MP2	SEM[2]	*P* – value[3]	Linear	Quadratic
Feedlot							
Initial BW, lb	55.8	62.4	65.0	4.59	0.36	0.18	0.71
Final BW, lb	131.6	138.2	139.4	4.87	0.48	0.27	0.65
ADG, lb/d	0.53	0.55	0.53	0.02	0.82	0.79	0.59
DMI, lb/lamb/d	2.25	2.31	2.47	0.07	0.09	0.04	0.66
G:F, lb gain:lb DMI	0.24	0.24	0.22	0.02	0.60	0.35	0.73
Morbidity,[4] %	13.6	31.8	9.1	10.0	0.12	0.69	0.04
Carcass characteristics							
HCW, lb	71.9	71.2	71.2	2.84	0.99	0.89	0.92
Dressing percentage, %	49.9	49.4	49.3	0.46	0.62	0.38	0.65
LM area, in^2	2.56	2.54	2.59	0.09	0.94	0.83	0.81
Back fat thickness, in	0.28	0.28	0.24	0.02	0.56	0.30	0.96
Body wall thickness, in	1.10	0.91	0.98	0.06	0.40	0.41	0.29
Leg score[5]	12	12	12	0.3	0.55	0.54	0.39
Conformation score[5]	12	12	12	0.3	0.86	0.59	0.93
Flank streaking[6]	396	409	398	18.2	0.83	0.96	0.54
Quality grade[5]	12	12	12	0.3	0.78	0.97	0.48
Yield grade[7]	3.2	3.0	2.9	0.25	0.56	0.30	0.96
BCTRC,[8] %	45.16	45.69	45.69	0.38	0.50	0.30	0.53

[1]Maternal dietary treatment: 60MP2: 60% of metabolizable protein of 100MP2; 100MP2: 100% of the metabolizable protein requirement; and 140MP2: 140% of the metabolizable protein requirement.
[2]Greatest SEM presented (n = 20 for 60MP2, n = 22 for 100MP2, and n = 20 for 140MP2).
[3]*P*-value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Percentage treated for illness during the feedlot phase.
[5]Leg score, conformation score, and quality grade: 1 = cull to 15 = high prime.
[6]Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.
[7]Yield grade = (back fat thickness × 10) + 0.4.
[8]Percent boneless, closely trimmed, retail cuts (% BCTRC) = [49.936 – (0.0848 × HCW, in) – (4.376 × back fat thickness, in) – (3.53 × body wall thickness, in) + (2.456 × LM area, in^2)].

Table 7. Effects of maternal metabolizable protein supplementation on ewe lamb growth and reproductive performance in year 2

	Maternal Dietary Treatment[1]					Orthogonal Contrasts[4]	
Item	60MP2	100MP2	140MP2	SEM[2]	*P* – value[3]	Linear	Quadratic
Birth weight, lb	9.9	9.9	10.4	0.46	0.62	0.43	0.52
Weaning BW, lb	32.4	37.3	35.3	1.61	0.07	0.14	0.09
Final BW,[5] lb	131.2	139.1	126.1	4.76	0.14	0.37	0.07
ADG, lb/d							
Birth to weaning	0.40	0.44	0.37	0.02	0.03	0.25	0.01
Weaning to final[6]	0.51	0.55	0.51	0.02	0.48	0.79	0.23
Birth to final[6]	0.49	0.51	0.46	0.02	0.17	0.55	0.07
Breeding in first 17 days,[5] %	84	94	70	9.0	0.12	0.18	0.09
Total lambing,[6] %	19	28	26	10.2	0.76	0.57	0.65
Lambing to first 17 days,[7] %	86	88	83	15.4	0.98	0.91	0.86
Lambing to second 17 days,[7] %	14	13	17	15.4	0.98	0.91	0.86
Lambing rate[8]	0.23	0.33	0.26	0.12	0.78	0.80	0.52
Lamb birth weight, lb	10.4	10.4	7.9	0.86	0.05	0.04	0.14

[1]Maternal dietary treatment: 60MP2: 60% of metabolizable protein requirements; 100MP2: 100% of metabolizable protein requirements; and 140MP2: 140% of metabolizable protein requirements.
[2]Greatest SEM presented (n = 31 for 60MP2, n = 18 for 100MP2, and n = 23 for 140MP2).
[3]*P*-value for the F test of the mean.
[4]*P*-value for linear and quadratic effects of increasing metabolizable protein concentrations.
[5]Final BW observed at the end of the 128 day growth period beginning at weaning.
[6]Weaning to final indicates the ADG from weaning to the final BW measured on d 128 of the 128 day growth period. Birth to final indicates the ADG from birth to the final BW measured on d 128 of the 128 day growth period.
[5]Percentage of ewe lambs per treatment having breeding marks in the first 17 days of the breeding season.
[6]Total percentage of ewe lambs lambing per ewe lamb exposed per maternal dietary treatment.
[7]Percentage of ewe lambs lambing that were bred during the first 17 days post-ram turnout and the second 17 days post-ram turnout.
[8]Lambing rate: number of lambs born per ewe exposed to rams.

Effects of rumen-protected arginine supplementation during gestation in ewes on postnatal offspring performance[1]

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Maternal under nutrition can have serious negative effects on fetal development and postnatal outcomes, and is relatively common in grazing ewes (Wu et al., 2006). For this reason, we supplemented pregnant multiparous ewes that were restricted in nutrition with a rumen-protected arginine supplement in an attempt to mitigate negative consequences of compromised maternal nutrition during gestation. We found that lambs from restricted ewes had reduced birth weights and that providing a rumen-protected arginine supplement to ewes during gestation recovered lamb body weight by 19 days of age. Additional research is needed to determine if arginine supplementation could be a means for producers to enhance postnatal lamb performance.

INTRODUCTION

Death losses in the United States sheep industry are notably higher in lambs than adult sheep. Most lamb death losses occur before reaching the age of being marked, docked, or branded (USDA, 2012). Neonatal lamb death is an economic issue and methods to enhance lamb growth, development, and health from a young age with a focus on reducing lamb morbidities and mortalities while simultaneously improving performance should yield benefits for producers.

Studies have shown that the body weights and gain potential of lambs may be heavily influenced by maternal nutrition (Wu et al., 2006, Meyer et al., 2010, Neville et al., 2010). Because most ewes maintain their pregnancies throughout late fall and winter, availability of high quality forages may be compromised and maternal under nutrition can result. In fact, it is estimated that grazing ewes in the western U.S. often don't meet even 50% of National Research Council (NRC) recommendations; clearly supplementation is critical in these instances (Wu et al., 2006). If maternal under nutrition occurs throughout pregnancy, fetal growth and postnatal outcomes can be compromised. Developing offspring from undernourished ewes often are at higher risk of several animal health complications including respiratory diseases, which are implicated as one of the highest non-predator causes of lamb death loss in the U.S. (Wu et al., 2006, USDA, 2012).

Arginine, an amino acid, is a potential supplement that may help to circumvent under nutrition of grazing ewes. Arginine, among numerous other functions, serves as a precursor to nitric oxide and polyamines (Wu and Morris, 1998, Kwon, 2003). Nitric oxide is a known vasodilator which serves to increase blood flow to the fetus, and in turn transports more nutrients to the placenta for fetal development (Martin et al., 2001). Polyamines play various roles in placental health and development, most notably in regulation of angiogenesis, or the formation of new blood vessels. Similarly to nitric oxide, these polyamines may stimulate blood flow and consequently increase nutrient supply to the placenta throughout gestation (Kwon, 2003). We hypothesize that ewes supplemented with arginine throughout pregnancy will have a greater amount of nutrients available to the fetus during development, and their lambs will show more advanced development evidenced by increased weight gain.

PROCEDURES

Ewes. Thirty-two multiparous western white-face ewes were obtained from Hettinger Research Extension Center in Hettinger, North Dakota. The ewes were confirmed pregnant via ultrasound, and randomly assigned to three treatments: control (**CON**), restricted (**RES**), and restricted with an arginine supplement (**RES-ARG**). Ewes were fed a pelleted diet containing 34% dehydrated alfalfa meal, 27% dehydrated beet pulp, 25% wheat middlings, 9% ground corn, 5% soybean meal, and a tracemineral premix exchanged for ground corn at the rate of 12 pounds per ton on an as fed basis. Control ewes were fed at 100% NRC requirements, while restricted ewes were fed 60% of NRC requirements, and the arginine supplemented group received a granular rumen-protected arginine supplement at 180 mg/kg BW daily. Rumen protected arginine supplements were mixed into 0.11 pounds of corn and fed once a day at 8:00 am. Dietary treatments were implemented at day 54 of pregnancy (standard deviation of start date was 3.89 days). Ewes were housed in individual pens in a temperature-controlled facility.

Lambing. A 24-hour ewe watch procedure was implemented during lambing. Lambs were tagged, weighed, and a blood sample collected immediately following birth. They received C, D, & Tetanus toxoid and vitamins A, D, and E injections post birth. These lambs were not permitted to nurse from their mothers, so artificial colostrum was administered according to requirements of the lamb indicated by weight (Lifeline Rescue Colostrum, APC, Ankeny, IA). Lambs were given 19.1 mL/kg BW colostrum at intervals of 0 and 2 hours post birth, and 25.5 mL/kg BW at intervals of 4, 8, 12, 16, and 20 hours post birth to achieve a total of 10.64g IgG/kg body weight.

Lambs. After 24 hours, lambs were gradually weaned off of bottles to teat buckets filled with milk replacer (Super Lamb Milk Replacer, Merrick's Inc., Middleton, WI). This milk replacer, along with water, was available to them ad libitum. In addition to the milk replacer, a mixture of alfalfa hay and creep feed (Form-A-Feed 20% Lamb Pre-Starter, Form-A-Feed Inc. Stewart, MN) was also available ad libitum. Curved crown rump and girth measurements were taken post birth, and at 19 and 54 days of age. Lambs were weighed at birth, 24 hours, 3, 7, 14 ± 3, 19 ± 3, 33 ± 3, 40 ± 3, 47 ± 3, and 54 ± 3 days of age. Weighing procedures and scales remained constant throughout the project.

RESULTS AND DISCUSSION

Body weights of lambs from CON ewes were greater ($P < 0.05$) than lambs from RES ewes at days 0 ($P = 0.04$), 3 ($P = 0.003$), 7 ($P = 0.03$), 14 ($P = 0.02$), 19 ($P = 0.004$), and 33 ($P = 0.012$). Lambs from RES and RES-ARG ewes had similar body weights at birth ($P = 0.68$), weighing less than lambs from CON ewes (Figure 1). Lambs from RES-ARG ewes tended to weigh less than lambs from CON ewes at birth and on day 7 ($P = 0.10$, $P = 0.08$, respectively), and weighed significantly less on day 3 ($P = 0.02$). However, by day 19 lambs from RES-ARG ewes weighed more than lambs from RES ewes ($P = 0.04$), and were more similar to weights of lambs from CON ewes ($P = 0.41$). At day 19, lambs from CON ewes weighed 26.40 pounds, lambs from RES ewes weighed 22.65 pounds, and lambs from RES-ARG ewes weighed 25.35 pounds (Figure 1). Although birth weights of lambs from RES and RES-ARG ewes were similar, the lambs from RES-ARG ewes caught up to the lambs from CON ewes over time (Figure 1).

Average daily gains are shown in Fig. 2. Compared to lambs from RES ewes, lambs from RES-ARG ewes had greater ADG on day 19 ($P = 0.04$) and numerically had higher ADG for each time period during this trial. At day 19, lambs from CON ewes were gaining 0.783 pounds per day, lambs from RES ewes were gaining 0.676 pounds per day, and lambs from RES-ARG ewes were gaining 0.780 pounds per day (Figure 2).

Table 1 shows differences in curved crown rump and girth measurements. Lambs from RES-ARG ewes were not different than lambs from CON ewes in girth ($P > 0.05$), and, were different from lambs from RES ewes on day 19 ($P =0.02$) . Girth measurements on day 19 showed lambs from CON ewes were 21.81 inches, lambs from RES ewes were 20.20 inches, and lambs from RES-ARG ewes were 21.50 inches (Table 1). The only difference observed for curved crown rump measurements was on day 54; lambs from RES-ARG ewes had greater curved crown rump than lambs from RES ewes ($P = 0.003$). Curved crown rump measurements on day 54 were 37.91 inches for lambs from CON ewes, 36.97 inches for lambs from RES ewes, and 39.31 inches for lambs from RES-ARG ewes (Table 1).

IMPLICATIONS

These results imply that supplementing ewes with arginine during pregnancy may circumvent the effects of under nutrition. By avoiding these deleterious consequences of poor weight gains, producers could expect to have more vigorous lambs and lower lamb mortality rates. This would ultimately translate in to higher profitability for producers.

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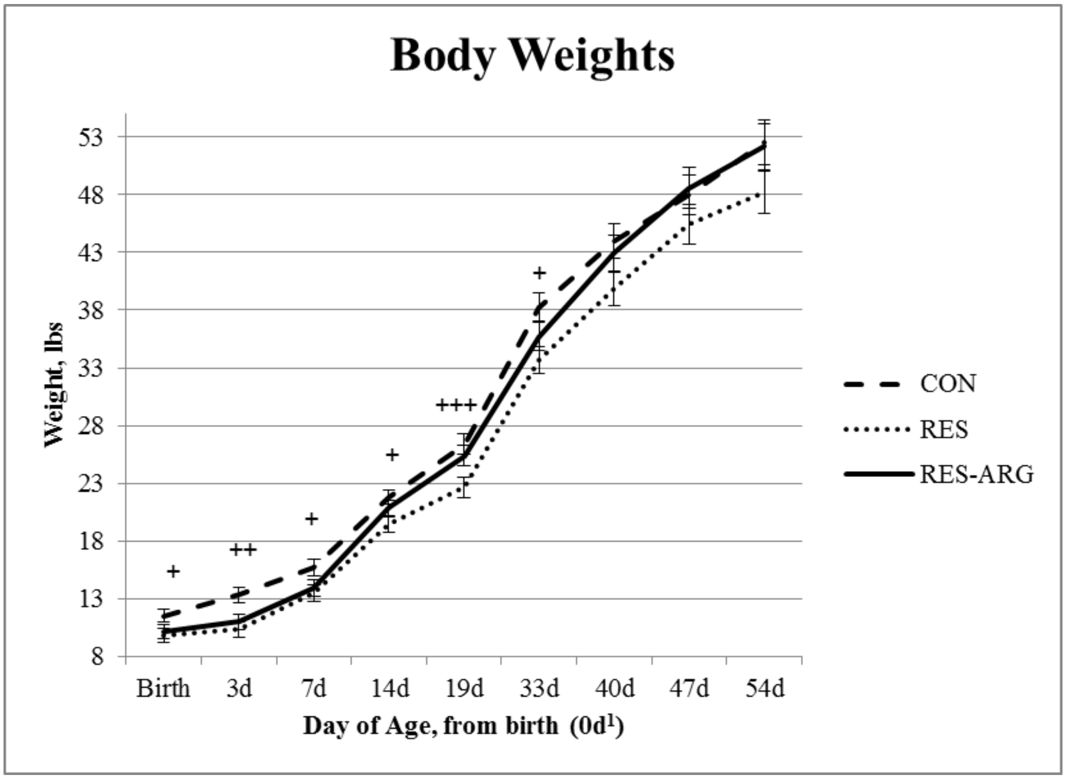
Table 1. Influence of nutrient restriction and rumen-protected arginine supplementation to ewes on offspring girth and curved crown rump measurements over time

Item	CON	RES	RES-ARG	SEM	*P*-value
Girth (in.)					
Birth (0d[1])	16.61[b]	15.19[a]	15.50[ab]	0.449	0.08
19d	21.81[b]	20.20[a]	21.50[b]	0.384	0.01
54d	27.89[b]	26.38[a]	27.43[ab]	0.486	0.10
CCR[c] (in.)					
Birth (0d[1])	21.62	20.71	21.69	0.585	0.43
19d	29.03	27.33	28.70	0.731	0.21
54d	37.91[ab]	36.97[a]	39.31[b]	0.502	0.01

[a,b] Means within a row with different superscripts differ ($P < 0.05$).
[c] CCR abbreviates curved crown rump.
[1] d abbreviates day.

Fig. 1. Influence of nutrient restriction and arginine supplementation of ewes on offspring body weights over time.



CON abbreviates control diet, RES abbreviates restricted diet, RES-ARG abbreviates restricted supplemented with arginine diet

+, ++, +++ Means within a day with different symbols differ

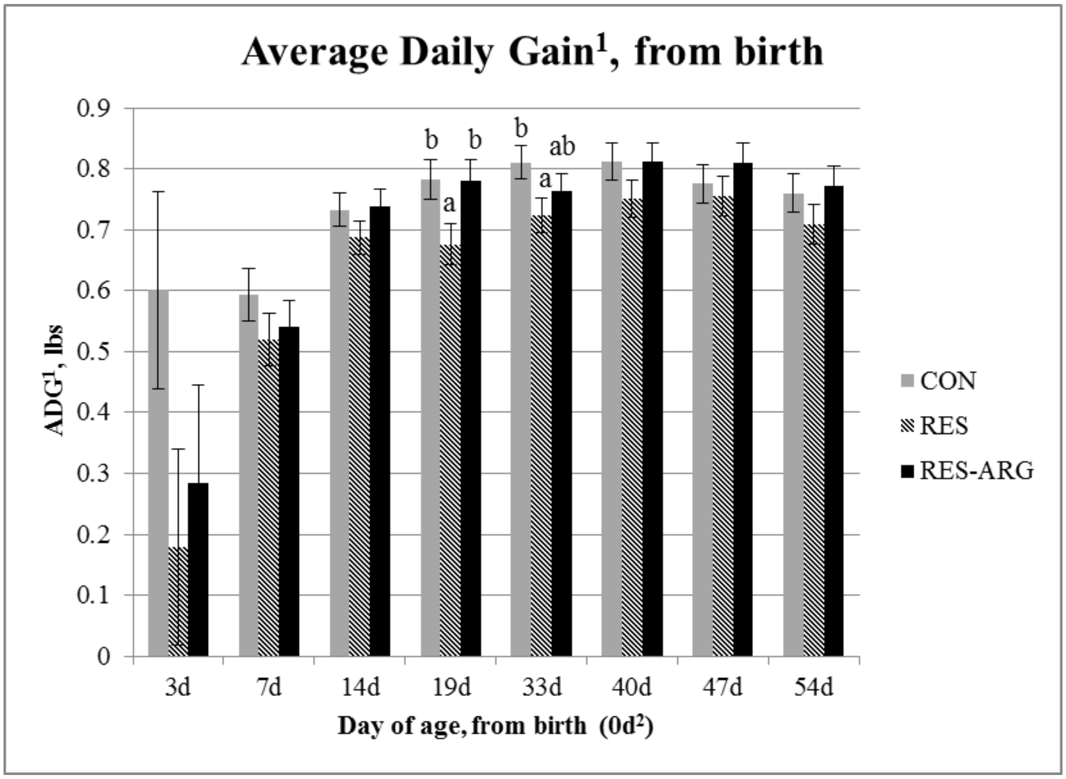
+ = CON is significantly different from RES, RES-ARG is similar to both ($P < 0.05$)

++ = RES is similar to RES-ARG, and significantly different from CON ($P < 0.05$)

+++ = CON and RES-ARG are similar, and significantly different from RES ($P < 0.05$)

[1] d abbreviates day

Fig. 2. Influence of nutrient restriction and arginine supplementation to ewes on offspring average daily gains over time.



CON abbreviates control diet, RES abbreviates restricted diet, RES-ARG abbreviates restricted supplemented with arginine diet

[a,b] Means within a day with different superscripts differ ($P < 0.05$)

[1] ADG abbreviates Average Daily Gain

[2] d abbreviates day

FLOCK CALENDAR OUTLINE

The following guidelines are neither inclusive nor intended to fit every sheep operation. Each operation is different, therefore, each “calendar event” should be tailored to each flock’s needs.

PRIOR TO BREEDING

1. Bag and mouth ewes and cull those that are not sound.
2. Replace culled ewes with top-end yearlings or ewe lambs.
3. Keep replacement ewes lambs on growing rations.
4. Evaluate sires:
   A. Be sure they are vigorous, healthy and in good breeding condition.
   B. Rams should be conditioned at least a month before breeding season. Flush rams in poor condition.
   C. Allow at least two mature rams (preferably three) or four buck lambs per 100 ewes.
5. Flush ewes:
   A. One pound grain/day two to five weeks before breeding (usually 17 days).
   B. If ewes are over-conditioned, the effect of flushing will be lessened.
6. Vaccinate ewes for vibriosis and enzootic abortion (EAE).
7. Identify all ewes and rams with ear tags, paint brands or tattoos.

BREEDING

1. The ovulation rate of a ewe tends to be lower at the first part of the breeding season. Vasectomized or teaser rams run with ewes through the first heat period tend to stimulate then and increase the ovulation rate at the second heat period.
2. Use a ram marking harness or painted brisket to monitor breeding. Soft gun grease with a paint pigment mixed in works well for painting the brisket. A color sequence of orange, red and black is recommended with colors being changed every 17 days.
3. Leave rams in NO LONGER than 51 days (35 days is more desirable).
   A. An exception may be with ewe lambs. Allowing them four cycles or 68 days may be beneficial.
4. Remove rams from ewes after the season (don’t winter rams with ewes).

PRIOR TO LAMBING (First 15 weeks)

1. Watch general heath of ewes. If possible sort off thin ewes and give extra feed so they can catch up.
2. Feed the poor quality roughage you have on hand during this period, saving better for lambing.
3. An exception to the above is feeding pregnant ewe lambs. They should receive good quality roughage and grain (about 20 percent of the ration) during this period.

LAST SIX WEEKS BEFORE LAMBING

1. Trim hooves and treat for internal parasites.
2. Six to four weeks before lambing feed 1/4 to 1/3 pound grain/ewe/day.
3. Shear ewe before lambing (with highly prolific ewes at least a month before is preferred). Keep feeding schedule regular and watch weather conditions immediately after shearing (cold).
4. Vaccinate ewe for enterotoxaemia.

5. Control lice and ticks immediately after shearing.
6. Four weeks before lambing increase grain to 1/2 to 3/4 pound/ewe/day (usually done immediately after shearing.
7. Give A-D-E preparations to ewes if pastures and/or roughage are or have been poor quality.
8. Feed selenium-vitamin E or use an injectable product if white muscle is a problem. Caution DO NOT use both.
9. Check facilities and equipment to be sure everything is ready for lambing.
10. Two weeks before lambing increase grain to 1 pound/ewe/day.

LAMBING

1. Be prepared for the first lambs 142 days after turning the rams in with the ewe, even though the average pregnancy period is 148 days.
2. Watch ewes closely. Extra effort will be repaid with more lambs at weaning time. Saving lambs involves a 24-hour surveillance. Additional help at this time is money well spent.
3. Pen a ewe and lambs in lambing pen (jug) after lambing, not before.
4. Grain feeding the ewe during the first three days after lambing is not necessary.
5. Be available to provide assistance if ewes have trouble lambing.
6. Disinfect lamb's naval with iodine as soon after birth as possible.
7. Be sure both teats are functional and lambs nurse as soon as possible.
8. Use additional heat sources (heat lamps, ect) in cold weather.
9. Brand ewes and lambs with identical numbers on same side. Identify lambs with ear tags, tattoos or both.
10. Turn ewes and lambs out of jug as soon as all are doing well (one to three days).
11. Bunch up ewes and lambs in small groups of four to eight ewes and then combine groups until they are a workable size unit.
12. Castrate and dock lambs as soon as they are strong and have a good start (two days to two weeks of age). Use a tetanus toxoid if tetanus has been a problem on the farm (toxoids are not immediate protection, it takes at least ten days for immunity to build).
13. Vaccinate lambs for soremouth at one to two weeks of age if it has been a problem in the flock.
14. Provide a place for orphaned lambs. Make decision on what lambs to orphan as soon after birth as possible for best success. Few ewes can successfully nurse more than two lambs.

END OF LAMBING TO WEANING

1. Feed ewes according to the number of lambs sucking. Ewes with twins and triplets should receive a higher plane of nutrition.
2. Provide creep feed for lambs (especially those born during the winter and early spring).
3. Vaccinate lambs for overeating at five weeks and seven weeks of age.

WEANING

1. Wean ewes from lambs, not lambs from ewes. If possible, remove ewes from pen out of sight and sound of lambs. If lambs have to be moved to new quarters, leave a couple of ewes with them for a few days to lead the lambs to feed and water locations.

2. Lambs should be weaned between 50 and 60 days of age when they weigh at least 40 pounds and are eating creep and drinking water. The advantage of early weaning is that the ewe’s milk production drops off to almost nothing after eight weeks of lactation.

2. Grains should be removed from the ewe’s diet at least one week prior to weaning and low quality roughage should be fed. Restriction of hay and water to ewes following weaning lessens the chance of mastitis to occur. Poorer quality roughage should be fed to the ewes for at least 10-14 days following weaning.

3. Handle the ewes as little as possible for about 10 days following weaning. Tight udders bruise easily. If possible, bed the area where the ewes will rest heavily with straw to form a soft bed for the ewes to lay on.

WEANING TO PRE-BREEDING

1. If ewes go to pasture, treat for internal parasites.

2. Feed a maintenance ration to the ewes. Put ewe lambs that lambed back on a growing ration once they have quit milking.

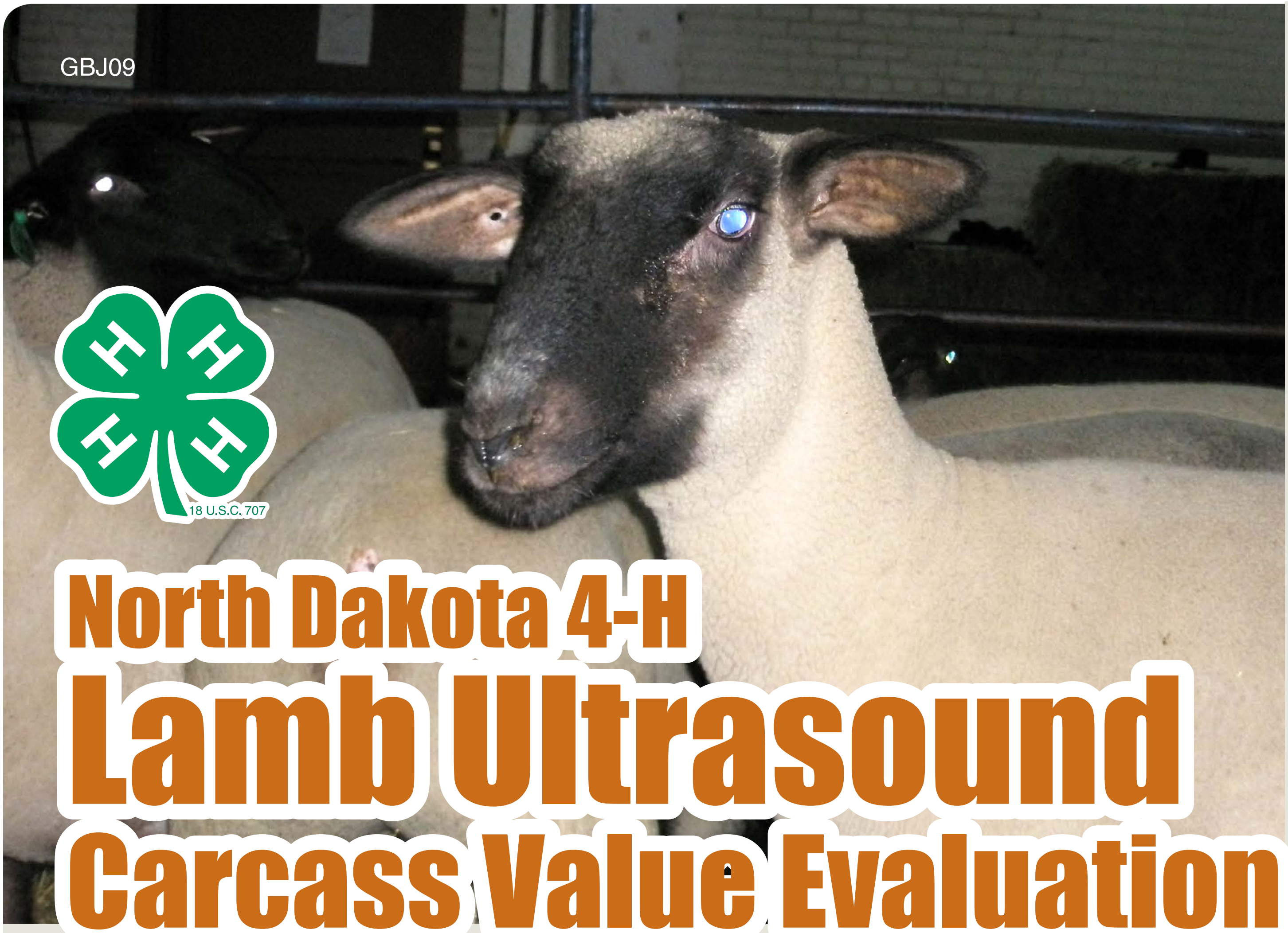
3. Adjust ewes condition so they can be effectively flushed for next breeding season. Don’t get ewes too fat prior to breeding.

REARING LAMBS ARTIFICIALLY (ORPHANS)- MANAGEMENT TIPS

Within 2 to 4 hours after birth, decide which lambs among those from multiple births you should remove. Look for the weaker, or smaller ones to choose for artificial rearing. It is important to make the decision early. Relatively weak lambs remaining with ewes can experience more stress than those reared artificially. Consider the following tips:

- It is essential that newborn lambs receive colostrums milk. Cow's colostrums will work if ewe's milk is not available. Do not dilute with water or warm too quickly if colostrums is frozen.
- Lambs should be removed from sight and hearing distance of ewes.
- Provide a warm, dry , draft-free area to start lambs.
- Use a good milk replacer that is 30% fat and at least 24% protein. Each lamb will require from 15 to 20 pounds of replacer to weaning.
- Lambs may require some assistance the first day or two to teach them to nurse on whatever feeding device is used.
- Start on nurser quickly, young lambs start easier.
- Self feed cold milk replacer after lambs are started. Milk replacers should be mixed with warm water for best results and then cooled down. Lambs feed cold milk well with less problems from scours and other digestive distrubances. Cold milk keeps better too.
- There is a Formaldehyde solution commercially avaliable that retards bacterial growth in milk (1cc/gallon milk).
- Hang a light over the milk replacer feeding device and dry ration feeder.
- Avoid placing young lambs with older lambs, as they may be pushed aside and may not be able to obtain the milk replacer. Remember that lambs nursing ewes drink 25 to 40 times per 24 hours. Best results have been obtained when lambs are fed in groups of 3 to 4 initially. After lambs are successfully trained, they can be handled in groups of 25.
- Inject lambs in the first few days with Iron Dextran, Vitamin A-D-E, and Selenium-Vitamin E. At 15 days of age, vaccinate for overeating (Colostridum perfringen type C & D).
- Provide lambs with a high-quality creep feed as soon as possible. Provide ample fresh water in front of lambs at all times. Do not feed hay or oats the first three week after weaning, as it encourages bloat. Caution! Do not feed leafy alfalfa until two weeks after weaning, as it encourages bloat.
- Wean lambs abruptly at 21-30 days of age. When to wean depends upon whether lambs are eating creep feed and drinking water. Newly weaned lambs will go back wards for several days. Don't be alarmed, they will make compensating gains later on.

GBJ09



North Dakota 4-H Lamb Ultrasound Carcass Value Evaluation

Rob Maddock, NDSU Meat Specialist
Reid Redden, NDSU Sheep Specialist
Christopher Schauer, Director
Hettinger Research Extension Center

The ultimate value of lamb is determined by the yield and quality of the carcass. This system was developed to evaluate the carcass merit of 4-H club lambs using data from ultrasound scans. Lambs are weighed and assigned a leg score, and loin muscle area, fat thickness and body wall thickness ultrasound measurements are taken between the 12th and 13th rib. The data gathered will be used to evaluate the carcass value of lambs.

NDSU EXTENSION SERVICE
North Dakota State University
Fargo, North Dakota
July 2013

Carcass Traits

Carcass traits used to evaluate lamb carcasses are based on industry standards for dressing percentage and ultrasound measurements of fat and muscling.

- **Hot carcass weight and dressing percentage:** The weight of the carcass after slaughter is referred to as hot carcass weight. The relationship between live weight and hot carcass weight is called dressing percentage, which is figured by dividing hot carcass weight by live weight. For lambs, the dressing percentage can vary between 45 and 57 percent. For this evaluation, we used a value of 54 percent, which is based on research data from club lambs. For example, a 150-pound lamb is estimated to have a hot carcass weight of 81 pounds (150 pounds x 54 percent).
- **Backfat thickness:** This is the thickness of the fat from the ribeye muscle to the outer surface of the carcass measured at the midpoint of the ribeye muscle at the 12th rib location (Figure 1). Backfat thickness is the only factor used in the assignment of yield grades. Figure 1 illustrates the location of the backfat measurement over the center of the ribeye, between the 12th and 13th ribs. Fat thickness may be adjusted up or down to account for unusual fat distribution at the point of measurement. Backfat on carcasses usually ranges from 0.1 to 0.5 inch.
- **Body wall thickness:** This is a measurement across the lean, bone and fat of the lower rib 5 inches from the midline of the carcass (Figure 1). This area accumulates excess fat in some animals and is an indicator of expected trimmed cut yield from the carcass. Body wall thickness usually ranges from 0.5 to 1.2 inches.
- **Ribeye area (REA):** This is an objective measure of muscling in lambs and is measured in square inches between the 12th and 13th ribs (Figure 1). REA measurements usually range from 1.5 to 4.0 square inches. REA is affected by the weight and muscularity of the live animal and provides a good estimate of the percentage of lean to bone in the carcass.
- **USDA yield grade:** U.S. Department of Agriculture yield grades are calculated by using the following formula: YG = 0.4 + (10 × adj. fat thickness). USDA yield grades (1, 2, 3, 4, 5) categorize carcasses into groups according to the expected yield of trimmed, retail cuts. Yield grade 1 has the highest expected yield and 5 the lowest. For example, a lamb with 0.15 inch of backfat will have a USDA yield grade of 1.9 (0.4 + (10 x 0.15).

1 describes the assignment of yield grades based on backfat ranges and the average yield of semiboneless cuts for each yield grade.

Table 1. Lamb Carcass Yield Grade Information.

Yield Grade	Backfat Range	Average Estimated % Semiboneless Yield
1	0.15 inch and less	50.3
2	0.16 to 0.25 inch	49.0
3	0.26 to 0.35 inch	47.7
4	0.36 to 0.45 inch	46.4
5	0.46 inch and greater	45.1

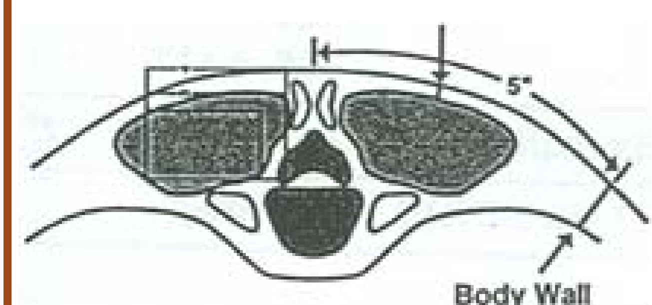


Figure 1. Locations of measurement of ribeye area, backfat thickness and body wall thickness are shown in this figure, which represents a cross section of the lamb carcass at the 12th rib. Ribeye area is the area of the longissimus muscle (ribeye).

- **Leg scores (Figure 2):** These are used to evaluate muscling subjectively. Variations in leg score do not affect yield grade but are used to evaluate the attractiveness and lean yield of the lamb carcass. Leg scores usually range from 15 (very thick muscling) to 9 (thin muscling). A leg score of 12 is considered average for lamb leg muscling (slightly thick muscling).

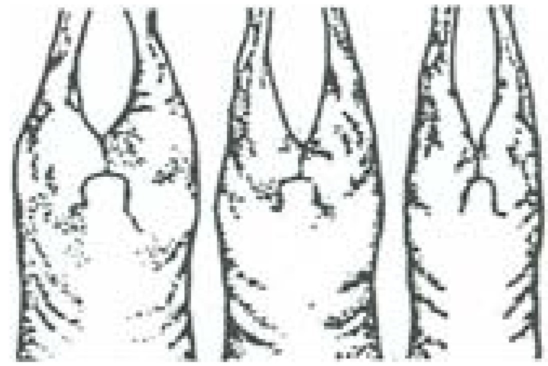


Figure 2. Examples of three leg scores are shown in Figure 2, with the thickest leg being a leg score 14, the middle example being a leg score 12 and the thinnest leg being a leg score 10.

Premium Certification Criteria

To be classified as North Dakota Premium Lamb, lamb must meet the following criteria. Lamb weight is multiplied by 54 percent to predict carcass weight. Carcasses must be between 50 and 85 pounds to qualify for premium certification. Lambs must be USDA yield grade 2 or 3, which is any lamb with an actual yield grade of 1.5 to 3.4. Lamb loin muscle area must be equal to or greater than the base area for the lamb's weight category. Lamb body wall thickness must be less than or equal to 1.25 inches. Lamb also must have a leg score equal to or greater than 12.

Table 2. North Dakota 4-H Premium Lamb Criteria.

Yield Grade	Carcass Weight (lbs.)	Required Ribeye Muscle Area (sq. in.)	Body Wall Thickness (in.)	Leg Score
1.5-3.5	50-55	≥ 2.8	≤ 1.25	≥ 12 leg score
	55-60	≥ 2.9		
	60-65	≥ 3.0		
	65-70	≥ 3.1		
	70-75	≥ 3.2		
	75-80	≥ 3.3		
	80-85	≥ 3.4		

Index System

If lambs make North Dakota premium lamb certification, the index system will rank lambs based on carcass merit. All premium lambs start with a base index value of 80. For each 0.1 inch increase in yield grade above 1.5, 0.25 point is deducted. For each 0.1 inch2 increase in loin muscle area above the base area for the lamb's weight class, lambs are given 1 point. For each 0.1 inch increase in body wall thickness above 0.8, lambs are deducted 2 points. Conversely, each 0.1 inch decrease in body wall thickness is rewarded with 2 points. Finally, lambs are given 2 additional points for each leg score above 12.

Table 3. North Dakota 4-H Lamb Live Lamb Carcass Index.

Yield Grade	Carcass Weight (lbs.)	Required Loin Muscle Area (sq. in.)	Body Wall Thickness (in.)	Leg Score
1.5	<50	2.7	Base = 0.8	Base = 12 leg score
	50-55	2.8		
	55-60	2.9		
	60-65	3.0		
	65-70	3.1		
	70-75	3.2		
	75-80	3.3		
	80-85	3.4		
	>85 lbs	3.5		
(+ 0.1 in. = - 0.25 units)	(+ 0.1 in. = - 2 units) (+ 0.1 sq. in. = + 1 unit)		(- 0.1 in. = + 2 units)	(+1 leg score = +2 units)

Source:
Lamb Carcass Evaluation, Bernie O'Rourke, Ron Russell, and Dennis Buege
UW-Madison, Department of Animal Sciences
www.dcqmas.org/carcass_contest/Lamb%20Carcass%20Evaluation.pdf

100-7-13

Presentations, Outreach and Publications

Christopher Schauer, Hettinger REC Director and Animal Scientist

Presentations and Outreach

Rambouillet Ram Test Results.
Ram Test Field Day, Hettinger, ND
March 16, 2013

WERA Sheep Symposium – Editor
Western Section ASAS 2013 meeting, Bozeman, MT
June 19, 2013

Sheep Nutrition for Beginners
Starter Flock Sheep School, Hettinger, ND
September 21, 2013

NSIP for Extension Agents
NDSU Extension and REC Fall Conference, Fargo, ND
October 23, 2013

Hettinger REC Research Update
NDSU Extension and REC Fall Conference, Fargo, ND
October 23, 2013

Winter Supplementation: Co-products, Selenium, Ram Lambs, and Random Thoughts
Tri-State Wool Growers Joint Convention, Jackson, WY
November 8, 2013

NDSU Shearing School
Hettinger, ND
November 23-25, 2013

NDSU and ASI Wool Classing School
Hettinger, ND
November 23-25, 2013

Hettinger REC Research and Outreach Update
North Dakota Lamb and Wool Producers Association, Mandan, ND
December 14, 2013

NSIP for Sheep Producers
North Dakota Lamb and Wool Producers Association, Mandan, ND
December 14, 2013

Publications

Van Emon, M.L., K.A. Vonnahme, P.T. Berg, R.R. Redden, M.M. Thompson, J.D. Kirsch, and **C.S. Schauer***. 2013. Influence of the level of dried distillers grains with solubles on feedlot performance, carcass characteristics, serum testosterone concentrations, and spermatozoa motility and concentration of growing rams. J. Anim. Sci. 91:5821-5828.

Kronberg, S.L., and **C.S. Schauer.** 2013. Cattle and sheep develop preference for drinking water containg grape seed tannin. Animal. DOI: 10.1017/S1751731113001262.

McGuire, D.L., D.W. Bohnert, **C.S. Schauer,** S.J. Falck, and R.F. Cooke. 2013. Daily and alternate day supplementation of urea or soybean meal to ruminants consuming low-quality cool-season forage: I. Effects on efficiency of nitrogen use and nutrient digestion. Livestock Sci. 155:205-213.

Cappellozza, B.I., Bohnert, D.W., **C.S. Schauer**, S.J. Falck, E.S. Vanzant, D.L. Harmon, and R.F. Cooke. 2013. Daily and alternate day supplementation of urea or soybean meal to ruminants consuming low-quality cool-season forage: II. Effects on ruminal fermentation. Livestock Sci. 155:214-222.

Eckerman, S.R., G.P. Lardy, M.M. Thompson, M.L. VanEmon, B.W. Neville, P.T. Berg, and **C.S. Schauer***. 2013. Effects of increasing dosage of zeranol implants on lamb growth, carcass characteristics, blood hormones, and nitrogen metabolism. J. Anim. Sci. 91:986-994.

Gearhart, A.L., D.T. Booth, K.K. Sedivec, and **C.S. Schauer***. 2013. Use of Kendall's Coefficient of Concordance to assess agreement among observers of very high resolution imagery. Geocarto International. 28(6):517-526.

Vonnahme, K.A., J.S. Caton, K.R. Maddock-Carlin, and **C.S. Schauer**. 2013. Maternal environment impacts fetal and offspring outcomes in sheep. J. Anim. Sci. Proc. 64:24-26.

Crane, A.R., R.R. Redden, M.L. VanEmon, T.L. Neville, L.P. Reynolds, J.S. Caton, and **C.S. Schauer**. 2013. Impacts of supplemental arginine on reproductive performance in sheep. J. Anim. Sci. Proc. 64:154-157.

Igathinathane, C., R. Redden, **C. Schauer**. 2013. Application of image processing for development of economical wool fiber thickness measurement for grading. Control ID: 1600767. 2013 ASABE Annual International Meeting.

Schwartz, C., K.A. Vonnahme, **C.S. Schauer**, S.M. Lonergan, K.J. Grubbs, W.L. Keller, and K.R. Maddock-Carlin. 2013. Effect of maternal metabolizable protein supplementation in isocaloric diets during late pregnancy on muscle fiber type and

enzyme expression in ovine fetal skeletal muscle. Amer. Meat Sci. Reciprocal Meat Conf:A2013-1088.

Schwartz, C.A., K.A. Vonnahme, C.S. Schauer, S. M. Lonergan, K.J. Grubbs, J.B. Schabb, W.W. Muhonen, W.L. Keller, and K.R. Maddock-Carlin. 2013. Proteomic analysis of fetal ovine skeletal muscle as influenced by maternal metabolizable protein supplementation in isocaloric diets during late pregnancy. J. Anim. Sci. 91(Supp. 2).

Lekatz, L.A., A. Reyaz, M.S. Sane, F. Yao, S.T. O'Rourke, C. Schwartz, M.L. VanEmon. **C.S. Schauer**, K.R. Maddock-Carlin, C.O. Lemley, J.S. Haring, and K.A. Vonnahme. 2013. Effects of metabolizable protein during gestation on vasoreactivity in response to angiotensin II and MRNA expression of angiotensin receptors in cotyledonary arteries. J. Anim. Sci. 91(Supp. 2):49 (Abstr.).

VanEmon, M.L., **C. Schauer**, A. Meyer, K. Maddock-Carlin, K. Vonnahme. 2013. Effects of maternal metabolizable protein supplementation during late gestation on wether offspring organ weights. J. Anim. Sci. 91(Supp. 2):129 (Abstr.).

Maddock, R., R. Redden, and **C. Schauer**. 2013. North Dakota 4-H Lamb Ultrasound Carcass Value Evaluation. NDSU Extension Service Bulletin. GBJ09.

Steichen, P.L., S.I. Klein, Q.P. Larson, K.M Bischoff, V.G.R Mercadante, G.C. Lamb, **C.S. Schauer**, B.W. Neville, and C.R. Dahlen. 2013. Effects of natural service and artificial insemination breeding systems on calving characteristics and weaning weights. 2013 NDSU Beef Research Report. p. 6-8.

Steichen, P.L., M.R. Schook, **C.S. Schauer**, B.W. Neville, and C.R. Dahlen. 2013. Effects of artificial insemination and natural service breeding systems on steer progeny backgrounding performance. 2013 NDSU Beef Research Report. p. 45-47.

Sorensen, V.L. Anderson, K. Maddock-Carlin, C.L. Engel, **C.S. Schauer**, K. Olsen, and R. Maddock. 2013. Effects of dietary forage concentration in finishing diets on growth and carcass characteristics of steers. 2013 NDSU Beef Research Report. p. 51-54.

Stackhouse, J.W., **C.S. Schauer**, and B.A. Geaumont. 2013. Analysis of a sheep cover crop graing trial in southwestern North Dakota. 2013 NDSU Sheep Research Report. 53:3-5.

VanEmon, M.L., M.M. Thompson, J.D. Kirsch, K.A. Vonnahme, and **C.S. Schauer**. 2013. Influence of the level of dried distillers grains with solubles on feedlot performance, carcass characteristics, blood metabolites, and semen quality of growing lambs. 2013 NDSU Sheep Research Report. 53:6-10.

Crane, A.R., R.R. Redden, M.L. VanEmon, T.L. Neville, J.S. Caton, and **C.S. Schauer.**

2013. Impacts of supplemental arginine on reproductive performance in sheep. 2013 NDSU Sheep Research Report. 53:18-21.

VanEmon, M.L., S.E. Eckerman, L.A. Lekatz, K.R. Maddock Carlin, K.A. Vonnahme, and **C.S. Schauer**. 2013. Effects of maternal metabolizable protein supplementation during the last 50 days of gestation on ewe performance and offspring performance from birth to weaning. 2013 NDSU Sheep Research Report. 53:26-30.

VanEmon, M.L., S.E. Eckerman, L.A. Lekatz, P.B. Berg, K.R. Maddock Carlin, K.A. Vonnahme, and **C.S. Schauer**. 2013. Effects of maternal metabolizable protein supplementation during the last 50 days of gestation on male and female offspring performance post-weaning. 2013 NDSU Sheep Research Report. 53:31-37.

John Rickertsen, Hettinger REC Research Agronomist

Presentations and Outreach

New Varieties and Research Update
Hettinger County Crop Imp. Asso., Regent, ND
February 5, 2013

New Varieties Update
West River Breeders, Reeder, ND
February 11, 2013

New Varieties and Research Update
Taylor Farm Institute, Taylor, ND
February 12, 2013

Booth & Poster
Area 4 SCD Research Results Conference
February 19, 2013

New Varieties and Research Update
Slope County Crop Imp. Asso., Amidon, ND
February 20, 2013

Moisture Control in Cropping Systems
Soil Health Workshop, Hettinger, ND
March 19, 2013

Hettinger REC Crop Tour
Hettinger, ND
July 8, 2013

Perkins County Crop Tour
Bison, SD
July 16, 2013

Small Grain Varieties
Bowman County Crop Tour, Scranton, ND
July 16, 2013

Small Grain Varieties
Stateline Crop Tour, Selfridge, ND
July 17, 2013

Small Grain Varieties
USDA-NGPRL Friends and Neighbors Day, Mandan, ND
July 17, 2013

Small Grain Varieties
Grant County Crop Tour, New Leipzig, ND
July 23, 2013

Small Grain Varieties
Hettinger County Crop Tour, Regent, ND
July 24, 2013

Ducks Unlimited Winter Wheat Reporting Session
Havana, ND
December 16, 2013

New Varieties and Research Updates
30th Western Dakota Crops Day, Hettinger, ND
December 19, 2013

Publications

North Dakota Alternative Crop Variety Trial Results for 2012. January 2013. NDSU Extension Service circular A574.

2012 Research Results, Area 4 SCD Cooperative Research Farm & USDA-NGPRL. Winter Wheat, Spring Wheat, Durum Wheat, Barley and Oat Variety Performance Results. In Proc. February 19, 2013.

Scott William Fausti, Md Rezwanul Parvez, Thandi Nleya, Patricia Johnson, Kenneth Olsen and **John Rickertsen** 2013. Forage Options and Drought Risk: A South Dakota Case Study. Journal of American Society of Farm Managers and Rural Appraisers. Vol. 76, No 1, Pp 167-184.

North Dakota Hard Red Spring Wheat Variety Trial Results for 2013. November 2013. NDSU Extension Service circular A574-13.

North Dakota Durum Wheat Variety Trial Results for 2013. November 2013. NDSU Extension Service circular A1067-13.

North Dakota Barley, Oat and Rye Variety Trial Results for 2013. November 2013. NDSU Extension Service circular A1049-13.

North Dakota Canola Variety Trial Results for 2012. November 2013. NDSU Extension Service circular A1124-13.
North Dakota and South Dakota Sunflower Hybrid Trial Results for 2013. December 2013. NDSU Extension Service circular A574.

North Dakota Dry Pea Variety Trial Results for 2013. December 2013. NDSU Extension Service circular A1469-13.

North Dakota Hard Winter Wheat Variety Trial Results for 2013. December 2013. NDSU Extension Service circular A1196-13.

30th Annual Western Dakota Crops Day Research Report. December 2013. NDSU Hettinger Research Extension Center Ag. Report No. 30.

Benjamin Geaumont, Hettinger REC Research Assistant Professor, Wildlife and Range Sciences

Presentations

Geaumont, B.A. 2013. History of public lands grazing and current research regarding a management indicator species. Soil Health and Land Management Workshop. March 2013. Hettinger, ND.

Geaumont, B.A., J.W. Stackhouse, and C.S. Schauer. 2013. Evaluating integrated crop-livestock-wildlife systems: a case study using annual forages and sheep. Soil Health Workshop. March 2013. Carrington, ND.

Geaumont, B.A. 2013. Habitat: it's where they live. 2013. Adams County Hunters Safety Course. April 2013. Hettinger, ND.

Geaumont, B.A. 2013. Hunting and wildlife. 4-H Youth Activities Day. Hettinger, ND.

Geaumont, B.A. 2013. Wildlife use of riparian ecosystems. ND Chapter of Society for Range Management, Annual Conference. Bismarck, ND, USA.

Geaumont, B.A. 2013. Wildlife, Agriculture, and Habitat. ND Wildlife Federation Youth Camp. Garrison, ND, USA.

Mazza, M.E., **B.A. Geaumont**, K.K. Sedivec, K. Larson, J. Norland, and C.S. Schauer. 2013. Selection of brood rearing habitat by Chinese ring-necked pheasant in southwest North Dakota. Society for Range Management, Oklahoma City, OK.

Stackhouse, J.W., K.K. Sedivec, and **B.A. Geaumont**. 2013. Use of home range estimators for evaluating ring-necked pheasant habitat use at multiple scales. ND Chapter of the Wildlife Society, Bismarck, ND.

Stackhouse, J.W., and **B.A. Geaumont**. 2013. Ring-necked pheasant: evaluation of winter survival and habitat use in SW North Dakota. Soil Health and Land Management Workshop. March 2013. Hettinger, ND.

Workshops Co-Organized

ND Reclamation – Bringing Ideas Together
February 26, 2013 – Dickinson State University, Dickinson, ND.

Soil Health and Land Management Workshop
March 19-20, 2013 – Hettinger Research Extension Center, Hettinger, ND.

Publications

Stackhouse, J.W., and **B.A. Geaumont**. 2013. Evaluation of three nest searching methods for ring-necked pheasant. The Prairie Naturalist 45:114-117.

Stackhouse, J.W., C.S. Schauer, and **B.A. Geaumont**. 2013. Analysis of a sheep cover crop grazing trial in southwest North Dakota. Hettinger Research Extension Center-North Dakota State University Sheep Research Report No. 53.

Advisory Board Meeting
Hettinger Research Extension Center
February 21, 2013

Board members present included Kat Weinert, Denise Andress, Julie Kramlich, Dennis Sabin, Justin Freitag, Cole Ehlers, Nathan Swindler, Joe Rohr, Terry West, Dean Wehri and joining via videoconference Tom DeSutter. Special guests included Rodney Howe, Tim Faller, Chris Boerboom and Gerald Sturn. Staff present included Christopher Schauer, Benjamin Geaumont, John Rickertsen and Cassie Dick.

After a noon lunch, the meeting was called to order by Chairman Dean Wehri at 12:45. Introductions were given.

Dean Wehri called for a motion to approve the minutes from the previous meeting. Joe Rohr motioned to approve the minutes, Tom DeSutter seconded and the motion to approve the minutes from the previous meeting passed, no opposing.

Dean Wehri called for any additions or changes to the agenda, no changes or additions were given. Dean Wehri called for a motion to approve the agenda, Nathan Swindler motioned to approve the agenda, Cole Ehlers seconded and the motion passed, no opposing.

Director's Report- Christopher Schauer (handout provided)

1. Chris Boerboom , Gerald Sturn, Tim Faller and Rodney Howe all spoke on legislative happenings: more funding to find and keep employees, put time into figuring needs because it takes a lot of time to get funds and the "2013-2015 Program Initiatives as Ranked by SBARE" was handed out.
2. Christopher Schauer spoke of the need for a weed scientist, housing for grad students and summer workers and to start putting together the priority list for the next session. He said the agronomy lab and livestock handling facility have a good start for funding, but nothing is certain until the session is done.

Animal Science Report- Christopher Schauer (handout provided)

1. Current progress towards goals
2. Need to put together new strategic plan

Range and Wildlife Report- Benjamin Geaumont (handout provided)

1. Evaluation of the interactions among black-tailed prairie dogs, birds and livestock update: Waiting to see if any protocol will change with research due to Black-footed Ferrets being observed close to research area. There are a lot of prairie dogs for the research trial.

Agronomy Report- John Rickertsen (handout provided)

1. More spring wheat and winter wheat breeding being done

2. Need a weed scientist position- more and resistant weed showing up
3. More drought tolerant corn coming out

Open Discussion

1. John Rickertsen was asked about sorghum- he stated that it likes warm soil, there is a need for more cold tolerant breeds, it can have better yield and be worth more than corn
2. John Rickertsen was asked of his alfalfa weevil knowledge- he stated that the first thing is the need to monitor your alfalfa

Election of Members

Nathan Swindler, Joe Rohr, Justin Freitag, Terry West and Jeremy Fordahl will have completed a three year term. Justin Freitag, Terry West and Jeremy Fordahl are eligible for reelection to another tree year term. All three members accepted another three year term on the board. Dean Wehri asked for a motion, Denise Andress motioned to reelect the members who can server another term, Cole Ehlers second. Dean Wehri asked for any discussion, there was none. Dean Wehri called for a vote, the motion passed, none opposing.

Dean Wehri asked for nominations to replace Nathan Swindler and Joe Rohr. Nathan Swindler nominated Jeremy Heather who has a grain and cattle operation. Joe Rohr nominated Matt Neiderman who has a grain and cattle operation. Dean Wehri asked for any other nominations, none were given. Dean Wehri asked for a motion, Joe Rohr motioned to accept the two nominations to be placed on the board, Nathan Swindler seconded. Dean Wehri asked for any discussion, there was none. Dean Wehri called for a vote, the motion passed, no opposing.

Dean Wehri asked for other nominations to fill a vacant spot left from an elected member who did not want to become a member. Wade Henderson was nominated. Dean Wehri asked for a motion, Terry West moved to remove Randy B. and replace him with Wade Henderson, Dennis Sabin seconds. No discussion was given, the motion passes with no opposing.

Christopher Schauer stated that he will contact all the newly elected members, explain our board to them and ask if they would be willing to serve as a member.

The next Advisory Board meeting will be held in conjunction with the Crop Day Tours.

Staff members were asked to leave for an executive session.

Advisory Board Meeting
Hettinger Research Extension Center
July 9, 2013

Board members present included Kat Weinert, Denise Andress, Julie Kramlich, Dennis Sabin, Justin Freitag, Cole Ehlers, Terry West, Dean Wehri, Tom DeSutter, Chuck Christman, Wade Henderson, Jeremy Fordahl, Matt Niederman and Jeremy Huether. Special guests included Tim Faller and Chris Boerboom. Staff present included Christopher Schauer, Benjamin Geaumont, Terri Lindquist, Alison Crane, Kelsey Egeland, Rebecca Turnquist and Rachael Lagein.

After a noon lunch, the meeting was called to order by Chairman Dean Wehri at 12:40. Introductions were given.

Dean Wehri called for a motion to approve the minutes from the previous meeting. Tom DeSutter motioned to approve the minutes, Cole Ehlers seconded and the motion to approve the minutes from the previous meeting passed, no opposing.

Dean Wehri called for any additions or changes to the agenda, no changes or additions were given. Dean Wehri called for a motion to approve the agenda, Chuck Christman motioned to approve the agenda, Julie Kramlich seconded and the motion passed, no opposing.

Chris Schauer thanked new board members and gave a short explanation about the Advisory Board: member's terms, meetings, NDSU Extension and Research, and Legislative Session background/structure.

Legislative Update & Director's report- Handout from Chris Schauer

1. Chris Boerboom- talked about legislative session results for Extension Service.
2. Tim Faller- spoke of SBARE history and how prioritizing items for the legislative session and how it helped research and extension in the state. He also talked on the legislative session and its results.
3. Chris Schauer- exciting legislative session for Hettinger, 20% increase in operating budget, new lab and position created.

Animal Science report- Handout from Chris Schauer

1. Alison Crane spoke on her project
2. Distillers grains
3. Alfalfa Weevils crop rotation- beef day topic?

Agronomy Report from John Rickertsen

1. Things are looking good for this year's variety and herbicide trials
2. Questions on canola, legume forages, alfalfa weevils and corn from board members

3. Grazing or leaving corn stalks related to disease- Crops day topic?

Range & Wildlife Report- Handout from Ben Geaumont

1. Data on how to manage prairie dogs
2. Cover crop/crop rotation questions

2010-2014 Strategic Plan

1. 5 year mission statement

Open discussion

Resolution for next SBARE session needs to be on the list by December, they take inputs

1. Housing Issue
2. Livestock facility plan- change to sheep/multi-species feeding facility
3. Need for another economist? More extension then research position and need better funding

Dean Wehri asked if the bunkhouse (housing) issue and Extension Economist were the initiative to be taken to SBARE? Terry West moved to accept initiatives, Cole Ehlers seconded. There was no discussion. Motion passed.

Funding for new Weed Scientist position

1. Denise Andress and Dean Wehri will assist in candidate search

The next Advisory Board meeting date will be set for the winter.

Staff members were asked to leave for an executive session.

2013 Personnel

Hettinger Research Extension Center

Christopher Schauer	Director/ Animal and Range Science
Ben Geaumont	Wildlife and Range Research Assistant Professor
John Rickertsen	Associate R/E Center Specialist/ Agronomy
Jeff Stackhouse	General Science Professional- Wildlife and Range Research Tech
Terri Lindquist	Finance Paraprofessional
Cassie Dick	Administrative Secretary
Don Stecher	Manager of Ag Operations
Nels Olson	Research Technician/ Agronomy
David Pearson	Research Technician/ Shepherd
Donald Drolc	Research Technician/Livestock
Clint Clark	Research Technician/Beef Herdsman
Stephanie Schmidt	Research Technician

Range and Wildlife Graduate Students
Amanda Lipinski
Mark Mazza

Animal Science Graduate Students
Alison Crane

The Hettinger Research Extension Center hires individuals on a part-time basis to help in the research effort. Many of these are students as well as local residence. We would like to acknowledge the following people who helped at some time during the past year: John White, Derrick Stecher, Samantha Obrigewitch, Jennifer Chancey, Alexandria Fulton, Dylan Hubl, Daniel Hoff, Myranda Kugel, Lauren Beshears, McKinsey Jahner, Kelsie Egeland, Rachael Lagein and Rebecca Turnquist.

Advisory Board Members

Dean Wehri, Chair	Mott, ND	Dennis Sabin	Morristown, SD
Cole Ehlers	Hettinger, ND	Lyle Warner	Baldwin, ND
Denise Andress	Hettinger, ND	Wade Henderson	Lodgepole, SD
Chuck Christman	Lemmon, SD	Jeremy Huether	Mott, SD
Justin Freitag	Scranton, ND	Julie Kramlich	Hettinger, ND
Terry West	Hettinger, ND	Jeremy Fordahl	Hettinger, ND
Kat Weinert	Hettinger, ND	Tom DeSutter	Fargo, ND
Matt Neiderman	Morristown, SD	Rodney Howe	Hettinger, ND

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