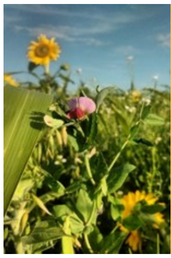

Grazing Management Practices to Enhance Soil Health in the Northern Great Plains

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Summary

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

Introduction

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

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

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

Procedures

A three-year ICLS project was initiated during the spring of 2020. NDSU Extension collaborated with producers to establish six demonstration sites in central North Dakota, along with a host site on the main campus of NDSU. An annual forage crop was subjected to two grazing density treatments: 1) moderate and 2) high.

Additionally, two forage utilization rates were evaluated: 1) 50% and 2) 75%. A non-grazed treatment served as the control. Treatments will be imposed for two years, followed by a cash crop.

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

Forage Establishment

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

Livestock and Grazing Management

Cattle were assigned randomly to grazing density treatments and carrying capacities were determined based on available forage production and estimated utilization. Stocking rates were determined by dividing the available forage by anticipated dry-matter intake per day, then dividing by 30 days of planned grazing to predict the number of cows per plot.

The available forage for 50% and 75% utilization treatments was calculated at 35% and 50% of the total forage produced, respectively (Meehan et al., 2018). The estimated dry-matter intake was based on recommendations in the Beef Cattle Handbook (National Research Council, 2016). The moderate stock density was based on the recommended stocking rate for a 30-day period.

The high stock density was set at double the moderate stock density and the grazing period reduced so as to ensure the treatment was not overgrazed. During 2020, turnout dates ranged from late August to early October.

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

Soil Sampling

Soil samples were collected to characterize physical, chemical and biological properties. Soil physical properties included bulk density, infiltration and soil aggregate stability collected pre- and post-treatment.

Six subsamples were collected from a similar soil series within each treatment prior to seeding of an annual forage crop. Samples also were collected from a nearby location that was managed as part of a traditional cash crop system. Soil chemical properties included soil nutrients, pH and organic matter collected annually with assessment of nutrient distribution occurring pre- and post-treatment only.

Subsamples for nutrient distribution were collected from each 1-acre subplot, whereas once yearly levels were extracted from a similar soil series within each treatment. Above-ground residue was removed gently at each sampling site prior to conducting the sampling technique.

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

Soil infiltration was determined by utilizing the Cornell Sprinkle Infiltrometer system (van Es and Shindelbeck, 2003). It consists of a portable rainfall simulator that is placed onto a single 9.5-inch inner diameter infiltration ring and allows for application of a simulated rainfall event.

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

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

Soil nitrate nitrogen (NO_3-N), carbon (C), phosphorus (P), potassium, pH, organic matter (OM), sulfate-sulfur (SO_4-S), zinc and copper (Cu) were determined from samples collected at 0 to 6 and 6 to 12 inches with a 0.7-inch-diameter soil probe. Soil nitrates (Vendrell and Zupancic, 2008) were measured using the Brinkmann PC910 Colorimeter. This colorimeter also was used to determine levels of P after applying the Olsen Test (Nathan and Gelderman, 2015).

Potassium was measured using an atomic absorption spectrophotometer. Zinc and copper were extracted with diethylene triamine penta acetic acid and also measured with an atomic absorption spectrophotometer (Nathan and Gelderman, 2015). Recommended chemical soil test procedures for the North Central Region (Nathan and Gelderman, 2015) were used to analyze C, pH, OM and SO4-S.

Forage Production and Utilization

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

Livestock Performance

A two-day body weight and body condition score was collected for the beef cattle at the Fargo location pre- and post-treatment; whereas, cattle at the demonstration sites were scored for body condition only. A visual scoring system developed by Wagner et al. (1988) was used to assess body condition.

Results and Discussion

Year One

Growing season conditions (Table 1) and field preparation appeared to impact germination of annual forage species and production (Table 2). Stocking rates were adjusted for locations with a significant amount of weed competition because forage utilization likely was reduced.

We also noted that seeding depth impacted germination of brassica species. Any location that seeded the annual forage crop to a depth greater than ¾ inch experienced little to no germination of brassicas.

Grazing start dates ranged from late August to early October 2020. The annual forage mix was designed

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

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

[1] Data obtained from the North Dakota Agricultural Weather Network (2020) from or near specific locations.

[2] Data obtained from National Weather Service (2020).

Table 2. Average forage production (pounds/acre [lbs/ac]), carrying capacity (animal unit months [AUM]/acre), number of grazing days and degree of use (%) by grazing treatment and location during 2020.

	Treatment					
Location	**Stock Density**	**Grazing Utilization (%)**	**Peak Production (lbs/ac)**	**Carrying Capacity (AUMs/ac)**	**Number of Grazing Days**	**Degree of Use (%)**
Fargo	High	50	4,892	1.40	11	38
		75	5,671	2.32	18	58
	Moderate	50	6,940	1.99	28	63
		75[1]	6,249	2.56	35	64
	Control	0	3,914			
Jamestown[2]	High	50	7,181	2.06	33	44
		75	6,490	2.66	33	52
	Control	0	6,548			
McKenzie	High	50	9,333	2.68	36	53
		75	7,714	3.16	41	68
	Control	0	8,079			
Napoleon[3]	High	50	5,593	0.72	30	52
		75	4,917	0.91	37	66
	Control	0	4,669			
Lehr	Moderate	50	12,725	3.65		51
		75	11,017	4.52		55
	Control	0	14,437			
McClusky[4]	Moderate	50	7,164	2.06	24	34
		75[5]	6,893	0.99	24	40
	Control	0	6,375			
Tappen[6]	Moderate	50	10,536	3.02	18	39
		75	8,782	3.60	18	56
	Control	0	6,444			

[1]Livestock pulled early due to inclement weather and limited feed.
[2]Livestock pulled early due to inclement weather and limited feed.
[3]Forage production consisted of 50% to 60% weeds. Stocking rate was adjusted accordingly.
[4]Livestock pulled early due to inclement weather.
[5]Forage production consisted of 65% weeds. Stocking rate was adjusted accordingly.
[6]Livestock pulled early due to issues with water.

Degree of use is based on the first two sections within each treatment.

to not only meet nutrient requirements of beef cattle, but also to maintain or improve ecological benefits.

These objectives are difficult to achieve when growing season conditions or field preparation negatively impact brassica germination. An early September frost also slowed or halted plant growth, which influenced the forage quality available to livestock. In year two, we hope to maintain a consistent depth of seeding across locations and begin grazing the treatments by mid- to late August.

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

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

Literature Cited

Costa, S.E.V.G.A., E.D. Souza, I. Anghinoni, P.C.F. Carvalho, A.P. Martins, T.R. Kunrath, D. Cecagno, F. Balerini. 2014. Impact of an integrated no-till crop-livestock system on phosphorus distribution, availability and stock. Agriculture, Ecosystems and Environment. 190:43-51.

Conservation Technology Information Center (CTIC). 2017. Report of the 2016-17 National Cover Crop Survey. Joint publication of the Conservation Technology Information Center, the North Central Region Sustainable Agriculture Research and Education Program, and the American Seed Trade Association. West Lafayette, Ind.

Faust, D.R., S. Kumar, D.W. Archer, J.R. Hendrickson, S.L. Kronberg and M.A. Liebig. 2018. Integrated crop-livestock systems and water quality in the Northern Great plains: Review of current practices and future research needs. Journal of Environmental Quality. 47:1-15.

Franzluebber, A.J., and J.A. Stuedemann. 2015. Does grazing of cover crops impact biologically active soil carbon and nitrogen fractions under inversion or no tillage management? Journal of Soil and Water Conservation. 70:365-373.

Meehan, M., K.K. Sedivec, J. Printz and F. Brummer. 2018. Determining carrying capacity and stocking rates for range and pasture in North Dakota. NDSU Extension, North Dakota State University, Fargo, N.D. https://www.ag.ndsu.edu/publications/livestock/determining-carrying-capacity-and-stocking-rates-for-range-and-pasture-in-north-dakota/r1810.pdf

Mikha, M.M., and C.W. Rice. 2004. Tillage and manure effects on soil and aggregate-associated carbon and nitrogen. Soil Science Society of America Journal. 68(3):809-816.

Nathan M.V., and R. Gelderman. 2015. Recommended chemical soil test procedures for the North Central Region. No. 1001. Missouri Agriculture Experiment Station, University of Missouri, Columbia, Mo.

National Research Council. 2016. Nutrient requirements of beef cattle. 8th rev. ed. The National Academies Press, Washington, D,C.

National Weather Service. 2020. Accessed Dec. 28, 2020. https://w2.weather.gov/climate

North Dakota Agricultural Weather Network. 2020. North Dakota State University, Fargo, ND. Accessed Dec. 28, 2020. www.ag.ndsu.edu

Reynolds, W.D., and D.E. Elrick. 1990. Ponded infiltration from a single ring: I. Analysis of steady flow. Soil Science Society of America Journal. 54:1233-1241.

Six, J., E.T. Elliott, K. Paustian and J.W. Doran. 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. Soil Science Society of America Journal. 62 (5):1367-1377.

USDA. 2014. 2012 Census of Agriculture – U.S. Data. USDA, National Agricultural Statistics Service. Washington, D.C.

USDA. 2019. 2017 Census of Agriculture – U.S. Data. USDA. National Agricultural Statistics Service. Washington, D.C.

van Es, H.M., and R.R. Schindelbeck. 2003. Field procedures and data analysis for the Cornell Sprinkle Infiltrometer. Dept. of Crop and Soil Sciences Research Series R03-01, Cornell University, Ithaca, NY.

Vendrell, P.F., and J. Zupancic. 2008. Determination of soil nitrate by transnitration of salicylic acid. Communications in Soil Science and Plant Analysis. 21. 13-16 (1990):1705-1713.

Wagner, J.J., K.S. Lusby, J.W. Oltjen, J. Rakestraw, R.P. Wettermann and L.E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. Journal of Animal Science. 66:603-612.

Photos by Erin Gaugler

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

Location	Cropping System	Soil Ecological Type	Depth (in)	NO_3-N (lbs/ac)	P (ppm)	K (ppm)	pH	OM (%)	SO_4-S (lbs/ac)	Zn (ppm)	Cu (ppm)
Tappen	ICLS	Very droughty loam	0-6	20	7.5	243	7.5	3.9	7.1	1.37	0.54
			6-12	12	6.0	162	7.8	2.0	5.5	0.42	0.55
	Annual crop		0-6	12	14.7	348	7.9	3.1	6.8	1.68	0.45
			6-12	8	2.7	195	8.1	2.3	5.3	0.66	0.48
Napoleon	ICLS	Droughty loam	0-6	20	11.8	205	6.2	3.6	10.0	0.91	0.73
			6-12	9	4.0	137	6.6	2.8	5.4	0.40	0.69
	Annual crop		0-6	14	6.3	138	6.4	4.7	6.0	1.01	0.72
			6-12	9	3.0	84	6.8	3.5	7.5	0.40	0.61
Wishek	ICLS	Loam	0-6	17	7.2	256	7.3	4.3	93.8	0.96	0.95
			6-12	7	2.6	173	7.6	2.9	86.2	0.57	0.96
	Annual crop		0-6	6	4.0	220	7.7	2.6	3.0	0.76	0.80
			6-12	10	1.7	143	7.8	2.0	17.2	0.37	0.69
Jamestown	ICLS	Loam	0-6	5	16.9	248	6.6	3.5	59.3	1.26	0.78
			6-12	5	4.9	139	7.1	2.2	86.1	0.53	0.70
	Annual crop		0-6	12	23.5	290	6.4	4.0	7.8	1.53	0.59
			6-12	13	7.7	177	6.7	2.5	6.5	0.68	0.58
McKenzie	ICLS	Loam	0-6	14	4.2	215	5.8	2.6	6.1	0.56	0.51
			6-12	8	2.2	110	5.9	1.7	6.9	0.25	0.52
	Annual crop	Very droughty loam	0-6	15	2.8	124	6.0	2.4	4.7	0.63	0.45
			6-12	9	1.2	71	6.9	1.5	6.2	0.25	0.45
McClusky	ICLS	Loam	0-6	31	9.7	427	7.0	3.9	27.1	1.04	0.61
			6-12	16	5.0	285	7.4	2.9	6.7	0.39	0.66
	Annual crop		0-6	22	11.3	328	6.8	3.9	5.5	0.56	0.83
			6-12	12	4.3	216	7.1	3.4	4.7	0.30	0.81
Fargo	ICLS	Clayey subsoil	0-6	7	8.5	315	7.3	5.3	14.1	0.90	2.19
			6-12	5	5.0	244	7.7	3.8	35.0	0.50	2.80
	Annual crop		0-6	53	22.4	385	7.3	5.7	11.4	1.22	2.79
			6-12	17	11.6	278	7.4	3.9	16.6	0.63	2.90