Enhancing profitability of soybean production through livestock integration

Joshua Wianecki[1], Miranda Meehan[1], Kevin Sedivec[2,3], Erin Gaugler[3], Zachary Carlson[1], Lindsay Malone[2], Colin Tobin[4], and Michael Ostlie[4]

The objective of this study is to identify the impacts of winter rye cover crop management through livestock integration on soil health, crop production, livestock performance, and economics. Livestock integration did not affect the function of winter rye as a cover crop, indicating potential for extended grazing periods in fall and spring on winter rye under favorable conditions.

Summary

A two-year study at the Central Grasslands Research Extension Center (CGREC) and Carrington Research Extension Center (CREC) investigated the effects of winter rye management with livestock integration on soil health, livestock performance, soybean production, and economics. The study evaluated four management scenarios: 1) dual grazing (fall and spring grazing), 2) spring grazing, 3) no grazing, and 4) no rye. The fall grazing period was short, ranging from 3 to 5 days, resulting in a loss of gain of 2.75 lb/day at CGREC and 6.28 lb/day at CREC. Livestock performance during spring grazing varied by location, with average gains of 0.54 lb/day at CGREC and an average loss of 1.48 lb/day at CREC. Spring forage yield of winter rye was not affected ($P < 0.05$) by fall grazing with the dual grazing treatment. Only soil nitrate levels were affected ($P < 0.05$) by grazing management, with lower nitrate-nitrogen in the no grazing treatment compared to no rye at CREC in the spring. Spring rye ground cover was not affected ($P > 0.05$) by fall grazing, indicating winter rye was not negatively affected by fall grazing. While total ground cover did not differ among treatments, all rye treatments decreased ($P<0.05$) weed cover regardless of grazing. Under favorable fall conditions, livestock integration into winter cover crops can extend the grazing season by utilizing quality forage without inhibiting the soil benefits of a winter cover crop.

Introduction

Cover crop use has expanded greatly in North Dakota in the last decade, increasing by 89% from 2012 to 404,267 acres in 2017 (USDA-NASS, 2019). However, the potential benefits of cover crops may not be completely attained under conventional cropping management. Integrated crop livestock systems offer producers methods of cover crop utilization with the potential to expand upon the benefits of cover cropping and create an economic return from livestock grazing (Archer et al., 2020). Typical winter rye (*Secale cereale*, L.) establishment in North Dakota occurs in late August through October. Herbage produced from winter rye during the fall is often left as cover and not grazed or hayed in North Dakota. In other regions within the US, especially the Central Plains, fall grazing of winter cover crops is more common, reducing winter feeding and housing costs (Holman and Luebbe, 2011). Extending the grazing season in both the fall and spring can increase the benefits of livestock integration and produce an additional economic return on the investment of cover cropping through a forage crop. The objective of this project was to investigate the effects of integrated livestock grazing with winter rye management on soil health, livestock performance, soybean production, and economics.

Procedures

A two-year project investigating the effects of integrating livestock grazing with winter rye management on soil health, livestock performance, soybean production, and economics was established in the fall of 2022. Two locations were selected in central North Dakota: one at the NDSU Central Grasslands Research Extension Center (CGREC) located 7 miles northwest of Streeter, N.D., and a second location at the NDSU Carrington

[1]Department of Animal Sciences, North Dakota State University, Fargo, N.D.
[2]School of Natural Resource Sciences, North Dakota State University, Fargo, N.D.
[3]Central Grasslands Research Extension Center, North Dakota State University, Streeter, N.D.
[4]Carrington Research Extension Center, North Dakota State University, Carrington, N.D.

Research Extension Center (CREC) located four miles north of Carrington, N.D. An approximately 30- to 40-acre block of cropland was identified at each location and divided into nine plots, of approximately 4.4 acres at CGREC and 3.3 acres at CREC. The plots were randomly assigned one of three treatments that were replicated three times: seeded to winter rye and dual (fall and spring) grazed, seeded to winter rye and spring grazed, and no grazing using a randomized block design. The no graze treatment was split to include two sub-plots using a split-plot design, with one sub-plot seeded to rye and one sub-plot receiving no rye and no grazing. The sub-plot with no rye and no grazing represented a traditional soybean cropping system and was used as the control.

Following harvest of the previous cash crop at each location, German millet (*Setaria italica*, L.) at CGREC and wheat (*Triticum aestivum*, L.) at CREC, fields were no-till seeded with winter rye. Prior to fall grazing, high-tension electric fencing was constructed between all plots. Water sources were provided for each grazing treatment. The fall grazing treatments grazed 5 days at CGREC with 4 bred heifers and 3 days at CREC with 5 bred heifers.

Spring grazing treatments were grazed for 16 days at CGREC by 9 open yearling heifers and 11 days by 6 open yearling heifers at CREC. All plots were treated with glyphosate following spring grazing treatments to terminate the winter rye and any weeds. Soybeans (*Glycine max*, [L.] Merrill) were no-till planted in 14-inch rows on June 9, 2023, at both locations into the remaining residue.

Soil samples were collected after winter rye seeding in fall and after soybean planting in spring. Sampling locations were stratified within the same soil series to reduce variability. Soil chemical analysis including organic matter, NO_3-N, Total N, P-Olsen, K, and total carbon was conducted across depths of 0-6 in and 6-12 in delivered to AgVise Laboratories (Northwood, N.D.) for analysis. Biological analysis, including arbuscular mycorrhizal fungi and microbial biomass carbon, was conducted across depths of 0 - 6 inches. Aggregate stability was collected as complete soil slices at 0 - 6 inches and delivered to AgVise Laboratories for analysis via automated slaking. Soil bulk density was collected at depths of 0 - 1.2 inches and 1.9-3.1 inches using an AMS (American Falls, ID) slide hammer bulk density corer. Water infiltration was conducted at two locations per plot using a Cornel sprinkle-infiltrometer. This system simulates a rain event within a 9.5-inch ring, and run-off volume is collected and used to calculate the total volume of water infiltration at field saturation.

Forage production was estimated pre- and post-grazing by clipping six 9.84-inch^2 quadrats randomly placed across each treatment with all winter rye within each frame clipped to ground level in each quadrat. Samples were dried at 60ºC for 48 hours to determine dry matter content. Pre-grazing yields were used to estimate carrying capacity and set stocking rate for the grazing period. Dried samples were composited and delivered to the NDSU Nutrition Lab for analysis of neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), and in-vitro dry matter digestibility (IVDMD). Absolute ground cover was evaluated pre- and post-grazing by visually estimating the percent cover of bare ground, residue, living rye, and/or weeds within each quadrat.

Animal bodyweights were recorded on two consecutive days and averaged for pre- and post-grazing bodyweights. Body condition score was visually conducted by two individual scorers according to the 9-point beef scoring system (Rasby et al., 2014). Body condition score was omitted during the fall season due to the short grazing period.

Results and Discussion

Winter rye production was 156 lb/acre and 198 lb/acre at the CGREC and CREC, respectively, in fall of 2022. Yields were impacted by a late planting date and dry conditions. This resulted in a short fall grazing period of 4 days and 1 head/acre at CGREC and 3 days and 1.5 head/acre at CREC. At both locations, grazing bred heifers resulted in weight loss of 2.75 lb/day and 6.28 lb/day at CGREC and CREC, respectively (Table 1).

Winter rye production was higher at CREC than CGREC due to differences in soils and precipitation between locations (Table 2). Spring production was 371 lb/acre in dual graze, 534 lb/acre in spring graze, and 406 lbs/acre in no graze at CGREC and 582 lbs/acre in dual graze, 819 lbs/acre in spring graze, and 709 lbs/acre in no graze at the CREC. While the dual grazed treatments had lower yields across locations, yields were not different ($P > 0.05$) between treatments. The grazing period was 16 days at 2.3 head/acre at the CGREC and 12 days at 1.8 head/acre at CREC. Spring performance varied greatly between locations; average daily gain was not different ($P > 0.05$) between grazing treatments at CGREC, with the dual grazing gaining 0.47 lb/day and spring grazing gaining 0.61 lb/day (Table 1). However, ADG in the dual grazing was lower ($P < 0.05$) than the dry lot treatment at CGREC. Grazing treatments at CREC grazed as blocks of three replicates rather than individual treatments due to confinement limitations in spring 2023. There was no difference ($P > 0.05$) in ADG among the three blocks, with an average loss of 1.4 lbs/day. However, all three blocks had a lower ADG than the dry lot at CREC.

Winter rye forage quality during the fall grazing period was greater ($P \leq 0.05$) than the spring grazing period, with greater CP concentration and lower NDF and ADF concentration (Table 2). Greater fall forage quality can be attributed to lower maturity of the newly established rye. Winter rye spring forage maintained CP levels throughout the grazing period at CGREC, with no changes found between the pre- and post-grazing levels. However, winter rye in dual grazing treatments was greater ($P \leq 0.05$) in CP at the end of the grazing period compared to the no graze. There was no difference ($P > 0.05$) in NDF and ADF concentrations between treatments pre- and post-grazing at CGREC. For CREC, there was no difference ($P > 0.05$) in forage quality between treatments. The higher quality observed for the grazed treatments at CGREC can be attributed to the grazing keeping the rye in a vegetative stage, which has higher forage quality than reproductive growth (Coblentz et al., 2020). This trend was not observed at CREC, as grazing was delayed, and the stocking rate was not high enough to prevent the rye from maturing during the grazing period.

Table 1. Livestock bodyweight and average daily gain (ADG) by treatment at Central Grasslands Research Extension Center (CGREC) and Carrington Research Extension Center (CREC) during the fall 2022 and spring 2023 grazing periods.

Location	Season	Treatment	Number of cattle	Grazing days	Average pre-graze bodyweight (lbs)	Average post-graze bodyweight (lbs)	ADG (lbs/day)
CGREC	Fall	Dual graze	4	5	988	974.2	-2.75
	Spring	Dual graze	9	16	693	701	0.47[a]
		Spring graze	9	16	688	698	0.61[a,b]
		Dry lot	9	16	686	706	1.28[b]
CREC	Fall[1]	Dual graze	5	3	1196	1177	-6.28
	Spring[2]	Block 1	6	11	1028	1013	-1.34[a]
		Block 2	6	11	1039	1019	-1.80[a]
		Block 3	6	11	1039	1026	-1.17[a]
		Dry lot	6	11	1035	1063	2.27[b]

[1]Animals escaped plot, ending grazing period
[2]Cattle grazed as blocked groups consisting of 3 plots per block
[a,b]Means with different letters are significantly different within column and location ($P \leq 0.05$)

Table 2. Winter rye forage yield and quality by Treatment at Central Grasslands Research Extension Center (CGREC) and Carrington Research Extension (CREC) during the fall and spring grazing periods in 2022 and 2023.

			Fall 2022[1]				Spring 2023			
Location	Treatment	Period	Forage yield (lb/ac)	Crude protein (%DM)	NDF (%DM)	ADF (%DM)	Forage yield (lbs/ac)	Crude protein (%DM)	NDF (%DM)	ADF (%DM)
CGREC	Dual	Pre-graze	156	23.43	32.87	16.25	371[a]	18.14[a]	40.44[a]	17.68[a]
		Post-graze	106	--	--	--	227[a]	20.05[a]	54.94[b]	26.66[c,b]
	Spring	Pre-graze	119	--	--	--	534[a]	16.32[a,b]	41.32[a]	18.79[a,b]
		Post-graze	--	--	--	--	304[a]	14.73[a,b]	58.39[b]	29.85[c]
	No Graze	Pre-graze	101	--	--	--	406[a]	--	--	--
		Post-graze	102	--	--	--	1618[b]	10.04[b]	62.61[b]	33.60[c]
CREC[2,3]	Dual	Pre-graze	198[a,b]	30.28	41.58	17.64	582[a]	14.13	52.30[a]	26.72[a]
		Post-graze	157[a]	--	--	--	663[a]	11.05	67.25[b]	37.5[b]
	Spring	Pre-graze	260[a,b]	--	--	--	819[a]	13.24	52.65[a]	27.23[a]
		Post-graze	--	--	--	--	1107[a]	9.33	69.87[b]	40.17[b]
	No Graze	Pre-graze	208[a,b]	--	--	--	709[a]	--	--	--
		Post-graze	294[b]	--	--	--	2105[b]	9.76	69.58[b]	40.15[b]

[1]Only grazing treatments were analyzed for Fall 2022
[2]Cattle escaped ending grazing period Fall 2022
[3]Cattle grazed as blocked groups Spring 2023
[a,b]Means with different letters are significantly different within column and location ($P \leq 0.05$)

Soil nitrate was higher ($P \leq 0.05$) in the no rye treatment compared to the no-graze treatment at CREC (Table 3). Dual grazing and spring grazing were not different ($P > 0.05$) in soil nitrate from either the no rye or no graze. There was no difference ($P > 0.05$) in soil nitrate content among treatments at CGREC. No differences were observed in all other soil chemical properties at either location. Soil bulk density was not different among treatments at either location.

Spring season ground cover was not affected by dual season grazing. All treatments containing rye provided weed suppression, having lower ($P \leq 0.05$) weed coverage than the no rye treatment across both locations. At the end of the spring grazing period, residue cover was significantly lower within the dual grazing treatment at CGREC and spring grazing treatment at CREC.

Even though climatic factors restricted winter rye performance, cattle grazing did not affect the function of rye as a cover crop. Notably, absolute ground cover was not impacted by fall or spring grazing. No rye plots at either location had greater weed cover, including yellow foxtail (*Setaria pumila*) and kochia (*Bassia scoparia*) post-grazing. The lack of effect on soil bulk density demonstrated no risk of compaction from fall or spring grazing cattle prior to cash crop planting. The continuation of the project through 2023 and 2024 may reveal other effects of cover crop management that are slow to develop over one growing season. Animal performance was low during the fall grazing season at both locations; however total animal loss of gain was minimal. Fall drought and late rye seeding slowed germination and establishment, only allowing a short grazing period which did not allow livestock to adjust, plus livestock may have had difficulty grazing a short crop. Fall grazing did not affect spring winter rye yields, which shows promise for fall grazing under more favorable fall growing conditions.

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Table 3. Soil Nutrients by Treatment at Central Grasslands Research Extension Center (CGREC) and Carrington Research Extension Center (CREC) Post-Grazing, Spring 2023.

Location	Treatment	Organic matter (%)	Total-N (%)	NO_3-N (lb/ac)	P-Olsen (lbs/ac)	K (lbs/ac)	T.C. (%)
CGREC	Dual graze	3.44	0.17	27.5	37.7	408	1.75
	No graze	3.39	0.17	17.5	21.7	391	1.75
	No rye	3.25	0.16	22.5	18.0	407	1.64
	Spring graze	2.58	0.13	24.0	34.0	392	1.37
CREC	Dual graze	2.93	0.15	24.0[a,b]	104.0	737	2.27
	No graze	2.70	0.17	16.3[a]	85.3	631	1.95
	No rye	3.23	0.17	35.3[b]	112.0	664	2.25
	Spring graze	2.68	0.15	18.3[a,b]	93.3	673	2.03

[a,b]Means with different letters are significantly different within column and location ($P \leq 0.05$)