Enhancing Profitability of Soybean Production Through Livestock Integration

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Background

Livestock integration has grown in interest in crop production as a method of diversifying and expanding economic opportunity. Integrated crop livestock systems (ICLS) offer economic advantages, while further enhancing the benefits of cover cropping to soils. Herbage produced from winter rye in the fall during this season is often left as cover and not grazed or hayed in the Northern Plains due to shorter growing seasons.

A two-year project was established at the Central Grasslands Research Extension Center and Carrington Research Extension Center to evaluate the effects of winter rye management through grazing on soil health, soybean production, livestock performance, and economics. Four management scenarios were evaluated 1) dual (fall and spring) grazing, 2) spring grazing, 3) no grazing, 4) no winter rye.

Research Objectives

1. Identify the impacts of winter rye management through grazing on soil health, soybean production, and livestock performance.
2. Determine the economic effects of winter rye management on crop and livestock production.

Materials and Methods

In the fall of 2022, a two-year project was established. Two locations were selected in central North Dakota, at the NDSU Central Grasslands Research Extension Center (CGREC) and the NDSU Carrington Research Extension Center (CREC). Each location was divided into 9 plots approximately 4 acres in size and randomly assigned one of four treatments: dual grazing,

spring grazing, no grazing, or no rye. The no graze treatments were split to include the no rye treatment for a total of 12 separate plots.

Following harvest of previous cash crop, fields were no-till seeded with winter rye in mid-September. Prior to fall grazing treatments, high tension electric fencing was constructed between plots. Water sources were provided for each grazing treatment. Fall grazed treatments were grazed in October and November. Spring graze treatments were grazed in mid-May. All treatments were treated with glyphosate following spring grazing to terminate the winter rye. Soybeans (*Glycine max,* L.) were no-till planted into remaining residue June 9, 2023, at both locations.

Soil samples were collected post-planting each season. Sampling locations were stratified to within the same soil series to reduce variability. Soil cores were collected for chemical (NO_3-N, P-Olsen, K, total nitrogen, pH, organic matter and total carbon), and biological (arbuscular mycorrhizal fungi and microbial biomass) properties. Physical soil properties were evaluated by bulk density, aggregate stability, and water infiltration.

Forage yield was estimated pre- and post-grazing by clipping. Pre-grazing yields were used to estimate carrying capacity and set stocking rate for the grazing period. Forage was sent to the North Dakota State University Animal Nutrition Lab for analysis of crude protein, NDF, and ADF. Absolute ground cover was evaluated during forage yield estimates both pre- and post-grazing by visually estimating the percent cover of bare ground, residue, living rye, and/or weeds.

Animal performance was determined by average daily gain during the grazing period and a visual body condition scoring. Body condition score was visually conducted by two individual scorers as according to the 9-point beef scoring system. Body condition score was omitted during the fall season due to the short grazing season. Animal weights were recorded across two days pre-and post-grazing.

Soybean productivity will be evaluated by assessing plant populations and through aerial imagery throughout the growing season. An unmanned aerial system (UAS) will be used to determine normalized difference vegetation index (NDVI) to compare plant health and density. Soybean seed yield will be measured with a combine at the end of the growing season.

Findings and Outcomes

Winter rye production was 156 lbs/ac and 198 lbs /ac at the CGREC and CREC; respectively, in the fall of 2022. Yields were impacted by late planting date and dry conditions, resulting in a short grazing period of 4 days and 1 hd/ac at CGREC and 3 days and 1.5 hd/ac at CREC. Both locations resulted in weight loss of bred yearling heifers during the fall grazing period of 2.75 lbs/day and 6.28 lbs/day at CGREC and CREC, respectively. Forage quality was high during the fall with high crude protein and lower NDF, which is expected during fall vegetative growth (Table 1).

Table 1. Winter Rye Forage Yield and Quality by Treatment at CGREC and CREC

			Fall 2022[1]				Spring 2023			
Location	**Treatment**	**Period**	**Forage Yield (lbs/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 ($p<0.05$)

Spring winter rye production was higher at the CREC than the CGREC due to differences in soil conditions and precipitation between locations. Winter rye production was 371 lbs/ac in the dual graze treatment,534 lbs/ac in spring graze treatment (SG), and 406 lbs/ac in no graze treatment at CGREC; and 582 lbs/ac in dual graze, 819 lbs/ac in spring graze, and 709 lbs/ac in

no graze at the CREC. There were no differences (P>0.05) in winter rye spring production between treatments. At CREC, grazing was delayed due to animal limitations. The spring grazing period was 16 days at CGREC and 11 days at CREC. Average daily gain (AGD) was not different (P>0.05) between grazing treatments at CGREC, with the dual graze gaining 0.47 lbs/day and spring graze gaining 0.61 lbs/day (Table 2). Grazing treatments at CREC were performed in blocks of three combined replicates due to confinement issues. There was no difference (P>0.05) in ADG among blocks at CREC, but all lost gain and were different to dry

Table 2. Livestock Bodyweight and ADG by Treatment

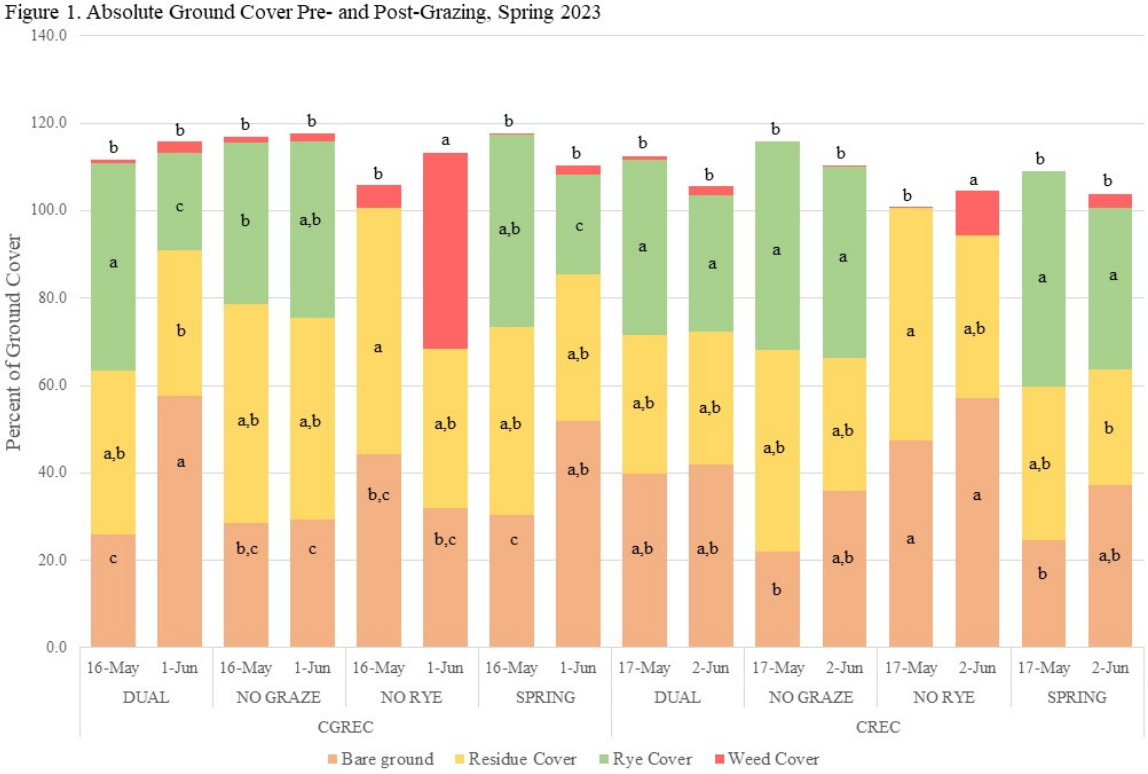
Location	Season	Treatment	Number of Cattle	Grazing Days	Average Pre-Graze Body Weight (lbs)	Average Post-Graze Body Weight (lbs)	ADG (lbs/day)
CGREC	Fall	Dual Graze	4	5	988	974.2	-2.75
	Spring	Dual Graze	9	16	693	701	0.47[a]
		Spring Graze	9	16	688	698	0.61[a,b]
		Dry Lot	9	16	686	706	1.28[b]
CREC	Fall[1]	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
[a,b]Means with different letters are significantly different within column and location

lot feeding.

Soil nitrate was higher in the no rye compared to the no graze treatments at CGREC. Dual graze and spring graze treatments did not differ (P>0.05) in nitrate to either no rye or no graze. No differences (P>0.05) were observed in all other soil chemical properties at either location. Bulk density did not vary between treatments at either location. No rye plots at either location were higher in weed cover post-grazing (Table 1); which included yellow foxtail (*Setaria pumila*) and kochia (*Bassia scoparia*) as dominant species at CGREC. While residue cover did nominally decrease (P>0.05) post-grazing, no treatments significantly changed in residue cover.

Figure 1. Absolute Ground Cover Pre- and Post-Grazing, Spring 2023



[a,b,c] Means with different letters are significantly different within cover type and location ($p < 0.05$)

Benefits to Industry

Initial findings from the first year of this project indicate the potential to utilize winter rye as a forage during the fall establishment period. Climatic factors limited growth in fall of 2022, negatively impacting forage yield and animal performance. Spring winter rye yield was not impacted by fall grazing and livestock performance increased with the longer grazing periods. Grazing did not impact the function of winter rye as a cover crop, with no changes in ground cover post-grazing. Grazing did not affect soil bulk density, indicates low risk of soil compaction during cover crop grazing. Economic impact has not been fully analyzed as potential effects on soybean yield and other responses are still being evaluated.

Results from the 2023-2024 portion of the project will aid in further understanding the impact of livestock integration on winter rye management. Observations through multiple seasons is important as soil properties often require multiple seasons change significantly. Initial results indicate that grazing winter rye may be beneficial in a soybean production system.