Impact of an extensive winter grazing system on soil health, forage production and forage quality

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The objective of this experiment was to determine the impacts of winter bale grazing on soil physical and chemical properties, forage production and forage quality. Results from the first growing season after grazing suggest that not only does winter bale grazing increase soil chemical and forage quality parameters, but soybean meal supplementation resulted in greater increases of soil nitrogen and the crude protein in the forage produced.

Summary

In year one, 72 crossbred backgrounding calves (initial body weight [BW] = 549 ± 233 lb) were utilized for a 44-day winter bale grazing study that evaluated the impacts on soil health (physical and chemical properties), forage production and forage quality. Calves were supplemented with dried distillers grains plus solubles (DDGS) or soybean meal (SBM) either daily or three times weekly. Soil and forage samples were collected at 0, 5, 10 and 15 ft from the bale center from three bales in each paddock; soils were collected at 0-6 and 6-12 inches. There was an increase ($P \leq 0.04$) in soil total nitrogen (TN), total carbon (TC) and total organic carbon (TOC) for SBM daily paddocks compared to the other three treatments. There was a decrease ($P = 0.005$) in the C:N ratio for SBM paddocks compared to control. There was no difference ($P = 0.104$) in average forage biomass yields between the bale-grazed paddocks and the ungrazed control. When evaluating the quality of the forage biomass, there was an increase ($P = 0.04$) in forage CP for SBM paddocks (13.20%) compared to DDGS paddocks (11.52%).

Introduction

Extended grazing systems, such as bale grazing, have started to gain popularity with producers in recent years due to the potential to be more efficient in nutrient recycling compared to drylotting (Jungnitsch et al., 2011). Research shows that bale grazing introduces higher nitrogen and phosphorus into the soil, and there is a positive relationship between bale grazing and nitrogen capture (Brummer et al., 2018). These extended grazing systems also allow producers to decrease production costs while enhancing profitability through reduced labor and feed costs (Undi and Sedivec, 2022). Feed costs make up a large portion of total production costs. Soybean meal has a higher cost relative to other protein sources, but it has a high concentration of protein and is a balanced source of essential amino acids, while dried distillers grains plus solubles is a cheaper feed source but lower in protein. When implementing an extended grazing system, not only are producers able to lower feed costs, but they also have the potential to improve soil health, forage production and forage quality. The objective of this study was to determine the impacts of winter bale grazing on soil health (both physical and chemical properties), forage production and forage quality.

Experimental Procedure

In the winter of 2023-2024, 72 crossbred backgrounding calves (initial BW = 549 ± 233) were used in a 44-day winter bale grazing study evaluating two protein sources and two supplementation frequencies on a field south of the NDSU Beef Cattle Research Complex in Fargo, North Dakota.

The study pasture was split into 15 paddocks of 40 ft × 400 ft (0.44 acres) using polywire electric fence. Grass hay round bales were individually weighed and placed in the middle of each paddock with 40 ft between each bale (10 bales per paddock). Cattle were given access to one bale at a time by moving the polywire electric fence. Cattle were assigned to one of four treatments: DDGS fed daily (DDGS-d), DDGS fed three times per week (DDGS-a), SBM fed daily (SBM-d) and SBM fed three times per week (SBM-a). There was also a non-grazed control to evaluate the impact of bale grazing on soil chemical properties, forage

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production and forage quality. Each treatment was replicated three times and randomly assigned to a paddock.

Before the start of the trial, baseline soil samples were collected at 0-6 and 6-12-inch depths. Five samples were taken for each depth in each paddock and then composited into one sample for each depth per paddock. At the end of the trial, soil samples were collected at 0, 5, 10 and 15 ft from the bale center from three bales in each paddock. Three samples were collected at random in the control paddocks. Samples were sent to AgVise Laboratories in Northwood, North Dakota, for chemical analysis (pH, total carbon [TC], total organic carbon [TOC], total nitrogen [TN], phosphorus [P], potassium [K], nitrate nitrogen [NN] and organic matter [OM]). Three bulk density samples were taken at the edge of three random bale site locations in each paddock, with the control paddock sample sites being chosen at random.

Forage biomass samples were collected by clipping 0.25 m^2 frames 0, 5, 10 and 15 ft from bale center. This was done from the three bale locations where we took soil samples. Samples were oven-dried at 50 degrees Celsius and weighed. Samples were ground through a 1-mm screen and analyzed by the NDSU Nutrition Laboratory for crude protein (CP), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium (Ca), phosphorus (P) and ether extract (EE).

Data were analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC). Significance was assigned at $P \leq 0.05$ with tendency between $0.10 \leq P > 0.05$.

Results and Discussion

Following bale grazing, there was an increase ($P \leq 0.04$) in TN, TC and TOC for SBM-d paddocks compared to the other three treatments (Table 1). Total nitrogen was as much as 0.10% higher in SBM-d, while TC and TOC were increased by as much as 0.82% and 0.81%, respectively. There was an increase ($P = 0.04$) in pH for SBM paddocks and daily (7.9 vs 7.8) supplemented paddocks, with pH being increased ($P = <0.0001$) at bale center (7.99) and 5 ft out (8.04) compared to 10 ft (7.75) and 15 ft (7.67). There was a decrease ($P = 0.005$) in the C:N ratio for SBM (9.97) paddocks compared to DDGS (10.41). There was also a decrease ($P = <0.0001$) in K concentrations moving out from bale center from 955.69 ppm at 0′ to 763.75 ppm at 15′. There was no difference ($P = 0.96$) in post grazed soil bulk density between the bale-grazed (0.92) and ungrazed control (0.92) paddocks.

Average forage biomass yields were not significant ($P = 0.104$) between the bale-grazed treatments and the ungrazed controls. However, when evaluating forage biomass yields for each distance from bale center within the bale-grazed paddocks, forage biomass decreased ($P = <0.0001$) at bale center and out to 5 ft from center. When evaluating the quality of the forage biomass, there was an increase ($P = 0.04$) in CP for SBM paddocks (13.20%) compared to DDGS paddocks (11.52%).

Previous studies show similar results as the current study. Chen et al. (2017), Donohoe et al. (2021) and Brummer et al. (2018) all saw increases in P and K in bale-grazed paddocks compared to ungrazed controls. Soybean meal paddocks had a decreased C:N ratio compared to the control. This is likely due to the increased concentrations of N in SBM compared to DDGS. Inclusion of N to the soil is important in the semiarid Great Plains as plant available N is often limited (Schuman et al., 1999). The freeze/thaw cycle that occurs in the northern Great Plains may be why there were no observed differences in soil bulk density (Liebig et al., 2011) single-enterprise production systems. However, concerns exist regarding the effect of livestock in integrated systems to cause soil compaction, thereby decreasing infiltration of water into soil. Such concerns are compounded by projections of more frequent high-intensity rainfall events from anticipated climate change, which would act to increase surface runoff and soil erosion. A study was conducted to evaluate the effects of residue management, frequency of hoof traffic, season, and production system (e.g., integrated annual cropping versus perennial grass. The decrease in forage production near bale center is also supported by research that has reported a decrease in production at and near bale center (Donohoe et al., 2021). Heavy accumulation of bale residue likely contributes to this decrease in production. Heavy accumulation of residue and continued decomposition can lead to potential increases in forage production in subsequent growing seasons (Brummer et al., 2018). Similar to both Brummer et al (2018) and Donohoe et al (2021), we also observed an increase in CP of forage biomass at bale center and a decrease moving out from bale center.

Our results suggest that producers can utilize an extended winter bale grazing system with backgrounding cattle while supplementing DDGS or SBM as few as three times per week and see improvements in soil health and forage quality parameters. Due to increased N concentration in SBM, there is an increase in soil N, which decreases the C:N ratio of the soil. Despite the decrease in year one forage biomass near bale center, there is research that supports an increase in production in subsequent growing seasons.

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Table 1. Post bale-grazing soil chemical analysis of bale-grazed treatments for depth 0-15 cm

Source	Freq	Distance, m	pH	NN, ppm	K, ppm	TN, %	TC, %	TOC, %	C:N
DDGS	A	0	$7.92^{A,a}$	11.17	899.00^{a}	0.36	3.82^{A}	3.64^{A}	$10.22^{b,c}$
		1.5	$7.87^{A,a}$	29.50	982.33^{a}	0.38	3.99^{A}	3.87^{A}	10.03^{c}
		3	$7.62^{A,b}$	10.22	805.44^{b}	0.38	4.09^{A}	3.99^{A}	$10.44^{a,b}$
		4.5	$7.66^{A,b}$	7.67	787.56^{b}	0.36	3.82^{A}	3.72^{A}	10.46^{a}
DDGS	D	0	$7.97^{B,a}$	11.83	940.44^{a}	0.38	4.12^{B}	3.94^{B}	$10.31^{b,c}$
		1.5	$8.02^{B,a}$	11.06	921.67^{a}	0.38	4.08^{B}	3.92^{B}	10.34^{c}
		3	$7.82^{B,b}$	7.89	809.67^{b}	0.36	4.08^{B}	3.92^{B}	$10.70^{a,b}$
		4.5	$7.70^{B,b}$	4.56	768.44^{b}	0.33	3.68^{B}	3.56^{B}	10.76^{a}
SBM	A	0	$8.00^{A,a}$	8.44	995.56^{a}	0.38	3.67^{A}	3.61^{A}	$9.57^{b,c}$
		1.5	$8.07^{A,a}$	4.83	997.11^{a}	0.39	3.81^{A}	3.73^{A}	9.58^{c}
		3	$7.83^{A,b}$	15.78	853.22^{b}	0.37	3.68^{A}	3.61^{A}	$9.94^{a,b}$
		4.5	$7.61^{A,b}$	7.44	788.67^{b}	0.35	3.81^{A}	3.70^{A}	10.57^{a}
SBM	D	0	$8.10^{B,a}$	7.94	987.78^{a}	0.40	4.12^{B}	3.99^{B}	$9.97^{b,c}$
		1.5	$8.19^{B,a}$	8.00	994.22^{a}	0.43	4.17^{B}	4.00^{B}	9.28^{c}
		3	$7.71^{B,b}$	21.33	873.67^{b}	0.42	4.49^{B}	4.37^{B}	$10.37^{a,b}$
		4.5	$7.70^{B,b}$	12.22	710.33^{b}	0.41	4.42^{B}	4.28^{B}	10.52^{a}
		SEM	8.19	29.50	997.11	0.43	4.49	4.37	10.76
	***P*-values**								
	Main effect	**SUPP**	**0.04**	0.70	0.24	**0.02**	0.58	0.40	**0.005**
		FREQ	**0.04**	0.62	0.67	0.10	**0.008**	**0.02**	0.22
		DIS	**<0.0001**	0.32	**<0.0001**	0.21	0.73	0.65	**0.003**
	Interactions	**SUPP x FREQ**	0.40	0.08	0.89	**0.04**	**0.03**	**0.04**	0.68
		SUPP x DIS	0.27	**0.02**	0.66	0.96	0.45	0.57	0.40
		FREQ x DIS	0.81	0.55	0.83	1.00	0.91	0.90	0.86
		SUPP x FREQ x DIS	0.26	0.47	0.89	0.52	0.62	0.52	0.64

[1]Source – DDGS: dried distillers grains plus solubles; SBM: soybean meal

[2]Freq (supplementation frequency) – a: three times per week; d: daily

[3]Distance – distance from bale center

[4]Items - OM: organic matter; NN: nitrate-nitrogen; P: Olsen-phosphorus; K: potassium; TN: total nitrogen; TC: total carbon; TOC: total organic carbon; C:N: carbon:nitrogen ratio

[5]SEM – largest standard error of the least squares means

[6]*P*-values - SUPP: protein source; FREQ: supplementation frequency; DIS: distance from bale center and their interactions.

[A-B] Uppercase letters denote significance ($P \leq 0.05$) for the main effect of supplementation frequency (FREQ). [a-b] Lowercase letters denote significance ($P \leq 0.05$) for the main effect of distance (DIS)

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