Impacts of Bale Grazing on Herbage Production, Forage Quality and Soil Health in South-central North Dakota

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Bale grazing is used to reduce feed and labor costs as well as improve manure distribution. The effects of bale grazing on forage production and quality and soil health is surveyed in this two-year study on four North Dakota ranches. Grass production varied, but forage quality was improved by bale grazing. Soil nutrient parameters were enhanced by bale grazing as compared with the control.

Summary

The effect of bale grazing on grass production six months after treatment varied based on ranch site location in our demonstration trials conducted in 2015 and 2016. The overriding variables that appear to affect grass production are distance between bales and stocking rate intensity (density and duration of time). Grass production was greater on the bale-grazed treatment, compared with the control treatment (no bales on site), 15 feet from the bale center; however, no difference was found within the zone 0 to 10 feet from the bale center six months after treatment.

Bale grazing enhanced grass crude protein and phosphorus content six months after treatment from the bale center out to 10 feet. Although bale grazing did not enhance total grass biomass production from within the 0- to 10-feet zone from the bale center, it increased grass crude protein content within this zone. Bale grazing also enhanced grass phosphorus content within the 0- to 5-feet zone of the bale center.

Soil nitrates, phosphorus and potassium at the 0- to 6-inch soil profile increased on the bale-grazed treatment at all distances from the bale edge six to nine months after treatment, with no increase on the control sites. The percent of organic matter at the same soil depth increased up to 1.4-fold at the bale-grazed sites, compared with the control sites.

Our field trials demonstrated that the added urine, feces and hay waste within the 10-feet zone of the bale center did not impact herbage production (no benefits or negative effects); however, these nutrients did enhance forage quality. Herbage within the 5-feet zone of bale center also had an enhanced phosphorus content, a direct result from the added urine and feces. This additional phosphorus is beneficial in meeting the requirements of grazing livestock, as well as removing excess phosphorus from the soil. Soil nutrient parameters were enhanced significantly at the bale grazed sites at the 0- to 6-inch soil profile from bale edge out to 12.5 feet, when compared with the control.

Introduction

Bale grazing is the practice of allowing livestock access to hay bales in a hayfield or improved pasture to reduce labor and feed delivery costs (Lardner et al. 2008). Livestock growers in the northern Great Plains practicing this technique also are interested in improving soil health and forage production through manure distribution while maintaining adequate livestock performance. Recently published data have shown a positive relationship between bale grazing and nitrogen capture, as well as forage growth (Jungnitsch et al. 2010, Kelln et al. 2012); however, local producer concerns in our region prompted the need for further applied research.

This project was conducted on four ranches in North Dakota to examine winter hay bale grazing effects on herbage production and nutritional quality six and 18 months after treatment. Parameters measured included: herbage production, nutritional quality, soil nutrient content, cow body condition and system costs.

Because bale grazing introduces higher nitrogen and phosphorus into a system, grazing on native pastures is not recommended. Therefore, this project was conducted on improved pastures planted to domesticated cool-season grasses. Herbage production, nutritional quality and soil nutrient content are presented in this report.

Procedures

Four ranches were selected on different ecological sites — claypan, thin loamy, loamy and shallow gravel — in south-central North Dakota. Sites consisted of improved, cool-season grass pastures/hay. Three of the sites had not been bale grazed previously.

Four bales of similar hay type were selected randomly per ranch to represent the bale-grazing (BG) treatment in September 2015. Bale grazing on all sites occurred from January through March 2016. Four control sites without bales

(C) were selected systematically on the same soil series, slope and plant community directly outside the bale-grazed area and sampled using the same protocol as the bale-grazed sites. See Figures 1 and 2 for project layout design and description.

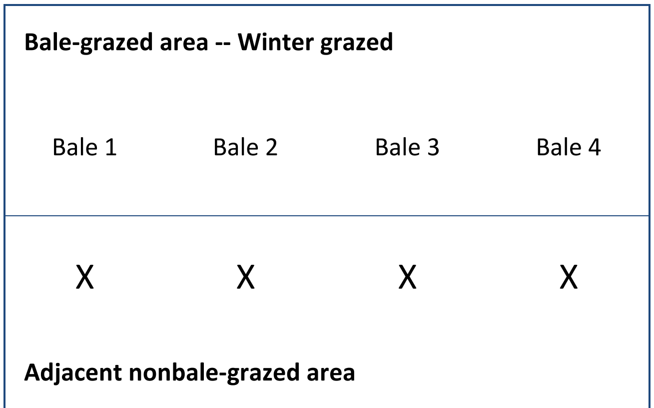

Figure 1. Example of bale-grazed study area showing a smooth brome grass pasture split into bale grazing treatment and the parallel nonbale grazing treatment (control), with "X" representing a corresponding sample location.

Herbage production was collected during peak production for cool-season grasses in North Dakota and before summer grazing occurred. Vegetation was clipped for biomass in late June or early July at four distance points (0, 5, 10, 15 feet) along each cardinal direction (16 total plots) from the bale center after cattle had grazed the bales in 2016 (Figure 2).

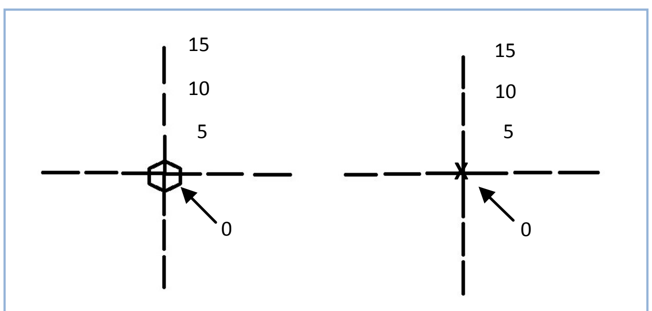

Figure 2. Example of collection locations from bale center and control center, 5, 10 and 15 feet from center for herbage production and soil nutrient content.

Grasses and forbs were separated and composited by plant form from all cardinal directions per bale distance point (four composited samples per bale distance). Hay residue was sampled at the same points and similarly composited to determine waste post-grazing, and to test for a possible relationship with herbage regrowth and quality.

Herbage samples were weighed, oven dried at 150°F and reweighed for moisture content. Wet chemistry nutritional analysis on the grass component was conducted at the North Dakota State University Animal Science Nutrition Lab. Analysis included crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), ash, calcium (Ca), magnesium (Mg) and phosphorus (P).

Soil samples were collected pretreatment in September 2015 and again 12 months later in 2016, or six to nine months after the bale-grazing treatment. Soil cores were collected at 0- to 6-inch and 6- to 24-inch depths from the same four bale treatment sites and four control sites that were used for herbage production. Soil parameters collected included penetrometer (compaction), electrical conductivity, Haney soil health calculation, nitrate, phosphorus, potassium, pH and organic matter.

Results and Discussion

Herbage Production. We found no difference ($P > 0.1$) in total grass biomass production among samples from the bale center, and 5 and 10 feet from the bale center on hay/pasture land that was bale grazed or on similar control hay/pasture land sites six months after treatment. However, bale grazing enhanced ($P < 0.1$) grass production 15 feet from the bale center (Table 1).

Table 1. Grass production at the on winter-grazed bales vs. no winter grazing six months after treatment (collected before grazing in late June/early July at peak production).

Treatment	Bale center	5 feet from center	10 feet from center	15 feet from center
	Pounds/acre[1]			
Bale grazed	5,274[a]	5,320[a]	4,613[a]	8,604[b]
Control	5,358[a]	5,823[a]	5,888[a]	6,160[a]

[1] Herbage production by treatment and distances from bale with the same letter (a, b) are not significantly different ($P > 0.1$).

When bales were placed close together (less than 15 feet), as seen at the Napoleon study site, the bale-grazed site produced from 21 to 172 percent less herbage, depending on distance from the bales, than the control site (Table 2). Because of the close bale spacing, manure and waste are naturally more prominent, as seen in the high residue levels (Table 2). Plus, stock density may have been lower than recommended, leaving a high level of residue on the ground.

Location	Bale distance average (feet)	Parameter	Bale center lbs./acre	5 feet from center lbs./acre	10 feet from center lbs./acre	15 feet from center lbs./acre
Tuttle	25 to 30	Residue from bale	28.5	16.0	7.1	NC[1]
		Bale-grazed production	2,860	3,620	5,083	NC
		Control production	3,103	3,740	6,779	NC
Wing	10 to 50[2]	Residue from bale	18.7	36.5	44.6	14.2
		Bale-grazed production	9,196	10,749	3,202	9,604
		Control production	5,695	8,423	5,789	6,125
Napoleon	15	Residue from bale	87.2	140.6	79.2	71.2
		Bale-grazed production	5,587	3,366	2,727	7,199
		Control production	8,775	7,865	7,432	8,679
Fort Rice	50	Residue from bale	69.0	71.2	9.8	11.6
		Bale-grazed production	3,454	3,544	7,440	9,009
		Control production	3,859	3,264	3,551	3,677

Table 2. Grass production and hay residue remaining six months after treatment at different distances from the bale when bales were grazed in early winter (January – March).

[1] NC = Not collected
[2] Spread unevenly throughout the field

When bales were placed 50 feet apart at the Fort Rice study site, bale grazing had no effect on grass production up to 5 feet away from the bale center (Table 2). However, bale grazing increased grass production by 109 to 145 percent at 10 and 15 feet from the bale center, respectively. This open spacing pattern reduces selection, more evenly distributes cattle and leaves less residue if cattle are forced to clean up the hay. This spacing causes higher levels of residue close to the bales but distributes manure more evenly away from the bales, helping explain bale grazing's positive effect on herbage production.

When the bales were placed 25 to 30 feet apart at the Tuttle study site, we found no difference between the bale-grazed sites and control sites (Table 2). Herbage production 10 feet away from the bale showed trends toward higher herbage production on the bale-grazed site, but without data from the 15-foot location, we were unable to determine if this production trend would continue to increase.

The Wing study site was the only location to show increased herbage production from bale grazing within the first 5 feet around the bale, with an increase of 28 to 61 percent. This site also showed a reduction in herbage production at 10 feet from the bale, that area with the greatest level of residue on the ground (Table 2).

However, where residue was low, as seen at 15 feet away from the bale, the bale-grazing site had an increased herbage production of 56 percent. This study site had bales spread irregularly, ranging from 10 to 50 feet. This uneven distribution of bales may have created uneven feeding patterns and increased the pecking order, creating these positive and negative impacts due to bale grazing within the same unit.

Forage Quality. Our demonstration trials exhibited that bale grazing increases ($P < 0.1$) the crude protein content of the grass portion of the vegetation six months after treatment (late June/early July) at the bale center out to 10 feet (Table 3). Grass crude protein content was greater ($P < 0.1$) than the control at the bale center, and 5 and 10 feet from the bale, but not ($P > 0.1$) at 15 feet from bale center.

These findings indicate that benefits from bale grazing occur throughout the zone within 10 feet of the bales. This benefit

Table 3. Grass quality parameters on winter-grazed bales vs. no winter grazing six months after treatment (collected before grazing in late June/early July at peak production).

Treatment	Bale center	5 ft. from center	10 ft. from center	15 ft. from center
		Crude protein (%) content[1]		
Bale grazed	17.2^{ax}	17.3^{ax}	15.9^{ax}	13.0^{bx}
Control	9.8^{ay}	9.8^{ay}	10.2^{ay}	10.9^{ax}
		Phosphorus (%) content[1]		
Bale grazed	0.30^{ax}	0.30^{ax}	0.27^{ax}	0.27^{ax}
Control	0.23^{ay}	0.23^{ay}	0.22^{ax}	0.24^{ax}
		Calcium (%) content[2]		
Bale grazed	0.48	0.44	0.41	0.38
Control	0.41	0.42	0.39	0.39
		Neutral detergent fiber (%) content[2]		
Bale grazed	61.7	60.9	62.4	64.4
Control	64.2	64.4	63.7	64.1
		Acid detergent fiber (%) content[2]		
Bale grazed	34.2	33.4	33.7	35.2
Control	33.9	34.7	33.7	34.1

[1] Nutritional parameters by treatment and distances from bale with the same letter (a, b) within row (treatment) are not significantly different ($P > 0.1$), and with same letter (x, y) within columns (between treatments) are not significantly different ($P > 0.1$).

[2] No differences ($P > 0.1$) were found between treatments or among distances.

is a result of added nitrogen from urine and fecal material concentrated within this 10-feet zone.

Grass phosphorus content was not ($P > 0.1$) different between bale treatment distances or among control distances (Table 3). However, the bale-grazing treatment increased ($P < 0.1$) grass phosphorus content when compared with the control at the bale center and 5 feet from the bale center six months after treatment (Table 3).

No differences ($P > 0.1$) in NDF, ADF or calcium content of the grass component were found between the bale-grazed and control sites six months after treatment (Table 3). Within our demonstration trials, bale grazing had no effect on NDF, ADF or calcium content within the 15-feet zone six months after treatment.

Soil Nutrient Content. Nitrates (NO_3-N), phosphorus and potassium increased on the bale-grazed treatment at all distances from the bale edge (2.5 feet from bale center), six to nine months after treatment (Table 4, next page), at the 0- to 6-inch soil profile. In contrast, these nutrients did not change significantly on the control sites at the same soil depth. On average across the distances from bale edge, nitrates increased six-fold, phosphorus 2.4-fold and potassium 2.8-fold at the 0- to 6-inch profile.

The percentage of organic matter increased 1.3-, 1.3- and 1.4-fold six to nine months after treatment at the bale edge (2.5 feet from center), 5 and 10 feet from bale edge; respectively (Table 4). In contrast, organic matter on the control site increased 1.1-fold after one year.

The Haney soil health calculation increased at all distances from the bale edge and on the control from 2015 to 2016. Because the control had a similar positive trend, compared with the bale-grazing treatment, the increase occurred due to environment or climatic effects and not due to the bale-grazing treatment during our sampling period (Table 5).

In contrast to the Haney soil health calculation, pH tended to decrease on all treatments and control sites (Table 5). Thus, the pH decline was not related to the bale-grazing treatment. Electrical conductivity (EC/salts) appears to have increased six to nine months after the bale-grazing treatment at all distances from the bale center (Table 5).

The control sites actually had a decline in EC from 2015 to 2016. Although we found, on average, a 25 percent increase in EC levels on the bale grazed treatment, EC levels remained under 0.5 mmhos/cm – an extremely low level.

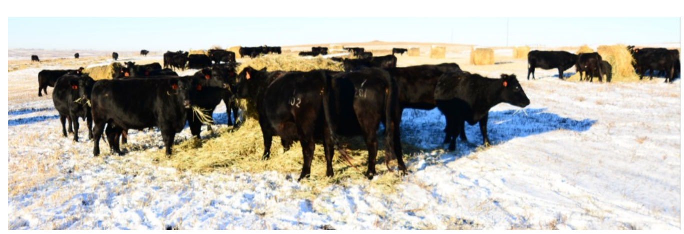

Table 4. Soil nutrient parameters in the 0- to 6-inch profile on winter-grazed bales in 2015 (pretreatment) and 2016 (six to nine month post-treatment).

	NO_3-N (lbs./ac)		Phosphorus (ppm)		Potassium (ppm)		Organic matter (%)	
Distance from bale edge	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Bale edge: 2.5 feet from center	11.4	74.0	11.3	30.0	366.7	888.9	3.9	5.2
7.5 feet from center	12.2	92.2	8.9	22.8	336.6	1047.5	3.9	4.9
12.5 feet from center	14.8	65.6	10.1	20.7	334.5	1007.3	4.1	5.6
Control (no bale grazing)	29.6	18.4	9.7	9.9	292.4	408.7	4.2	4.6

Table 5. Haney soil health calculation, pH and electrical conductivity (EC) in the 0- to 6-inch profile on winter-grazed bales in 2015 (pretreatment) and 2016 (six to nine month post-treatment).

	Haney soil health calculation (range: 1 to 50+)		pH		EC (mmhos/cm)	
Distance from bale center	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Center	19.7	38.8	7.6	7.0	0.31	0.44
5 feet from center	19.4	37.0	7.6	7.0	0.35	0.48
10 feet from center	19.2	35.7	7.6	7.1	0.32	0.41
Control (no bale grazing)	20.5	34.6	7.5	6.9	0.29	0.19

Although EC increased following the bale grazing treatment, the EC levels were still very low.

This project has provided insight on the impacts of bale grazing on herbage production, forage quality and soil nutrient composition when studying different scales of bale distribution and stocking densities. Because we had only one study site per bale spacing patterns, more work should be conducted to address this question of bale spacing and stocking density to further verify our findings and help explain the positive impacts bale grazing may create.

Conclusion

The effects of bale grazing on herbage production varied by ranch location; however, the distance between bales was the variable with the most impact on production. Residue and manure appeared to be a limiting factor affecting forage production where bales were spaced at 15 feet or less. The open spacing pattern of bales at 40 to 50 feet apart appeared to better distribute cattle and minimize hay residue.

Bale grazing positively affected crude protein and phosphorus content of grass growth during the growing season following the bale grazing treatment; however, the bale-grazing treatment had no effect on ADF, NDF or calcium content.

Bale grazing increased soil nitrate, phosphorus and potassium levels, irrelevant of distance from the bale edge. Bale grazing did not change pH or improve the Haney soil health calculation during the growing season following treatment.

A follow-up year is planned to determine if improvements may be seen 18 to 20 months after treatment on areas that were impacted negatively and if the positive benefits are retained for two growing seasons on the other sites.

Literature Cited

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