EFFECTS OF ROUND BALE FEEDING SITES ON SOIL FECAL BACTERIA AND NUTRIENT CONCENTRATIONS[1]

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Summary

An experiment was conducted over seven months (January to July 2003) to evaluate fecal bacteria and nutrient concentrations in soil surrounding round bale feeders at winter feeding sites. Six-inch soil samples were taken each month from a total of ten feeding sites, at distances of 10, 40, 70, and 100 feet from each feeder. Soil samples were taken before (January) livestock access to the sites, during (February, March, and April) the feeding period, and after (May, June, and July) cattle had been removed from the sites. Results indicate that fecal bacteria concentrations increased over the duration of feeding period and were greatest at close proximity to round bale feeders. The data suggest that environmental contamination due to fecal bacteria in the soil can occur up to 100 feet from the feeding site. For soil nutrients, the greatest increase generally occurred at 10 feet from the feeders, with few differences thereafter.

Introduction

Winter feeding sites have the potential for manure accumulation from greater animal density and mud accumulation after rainfall or snowstorms. These conditions may impact animal health and performance, as well as the environment. Often, winter feeding sites are located in areas that use streams or other waters of Kansas as their water source. Runoff, seepage, erosion, and direct access of livestock to water sources are among the means by which pollution can occur from winter feeding sites. However, both backgrounding and cow-calf producers use winter feeding sites, and do not fall into the EPA definition of a confined animal feeding operation. This does not, however, exempt producers from using management practices to prevent or reduce runoff into open water sources. Consequently, this study was designed to investigate the occurrence and concentration of bacteria and nutrients in the area surrounding round bale feeders to help producers make decisions about location of feeding sites to minimize environmental impacts.

Experimental Procedures

In 2003, a total of 10 winter feeding areas using round bale feeders, located in Riley, Washington, and Wabaunsee counties, were used. Soil samples were obtained monthly, before (January), during (February, March,

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April), and after (May, June, July) cattle were fed at each site. Twelve to fifteen 6-inch soil samples were taken and mixed within each distance of 10, 40, 70, and 100 feet surrounding each round bale feeder, at each sample date. A 6-inch sample was taken as a standard agronomic soil test measuring depth.

Subsamples of soil for fecal bacteria analysis were thoroughly mixed with sterile water or physiological saline and were subsampled for analysis of fecal coliforms, fecal *Escherichia coli* and fecal *Streptococci.* The membrane-filter technique was used for all bacteriological assays. Soil samples were also analyzed for nitrogen, sulfur, phosphorus (Bray P-1), magnesium, zinc, copper, organic matter, and dry matter, using methods from Recommended Chemical Soil Test Procedures for the North Central Region.

Data were analyzed as a completely randomized design according to the PROC MIXED procedures of SAS. Linear and quadratic polynomial contrasts were performed to determine the effects of increasing distance from the feeder on bacteria and nutrient concentrations. All bacteria and nutrient values were adjusted for dry matter before statistical analysis.

Results and Discussion

Soil Bacteria Analysis

As expected, no fecal bacteria, or only traces, were present at all distances in January, before the introduction of cattle to the feeding site (Table 1). Fecal coliforms were greater ($P<0.01$) for March, April, and May, compared with all other months, at distances of 10 and 40 feet. In addition, fecal coliform concentrations at 70 and 100 feet were greatest ($P<0.01$) for April, compared with all other sampled months, with May having greater ($P<0.04$) amounts than all other months except March. Linear increases in fecal coliforms were observed ($P<0.04$) for all months except January as samples were taken closer to the feeding site. By July, when cattle had been removed from the sites for 3 months, fecal coliform concentrations had returned to similar concentrations as in the pre-feeding period, except at 10 feet from the feeder.

Fecal *E. coli* concentrations reached their greatest concentrations of 3.67 $\log_{10}$ CFU/g and 2.25 $\log_{10}$ CFU/g in April for distances of 10 and 40 feet, respectively, and were greater ($P<0.03$) than all other months except March. At 70 and 100 feet from the feeder, fecal *E. coli* concentrations were greater ($P<0.01$) in April than all other months. A quadratic increase ($P<0.04$) was observed for fecal *E. coli* concentrations in March as distance from the feeding area decreased, whereas linear increases ($P<0.02$) occurred in the other months of the study.

At 10 feet from the feeding area, fecal *Streptococci* concentrations were greater ($P<0.01$) in March and April (4.12 $\log_{10}$ CFU/g) compared with all other months. The highest concentration at 40 feet was observed in March, and was similar to concentrations in both April and May, but was greater ($P<0.05$) than the other months. At 100 feet from the feeder, concentrations of fecal *Streptococci* reached the greatest concentration in July, and were similar to concentrations observed in April and May. There was a quadratic decrease ($P<0.02$) in fecal *Streptococci* concentrations from 10 to 100 feet in February, April and July, whereas there was a linear increase ($P<0.01$) in fecal *Streptococci* concentrations in March as distance from the feeder decreased.

Results indicate that fecal bacteria concentrations increased over duration of feeding period, and were greater at closer proximity to round bale feeders. The data suggest that environmental contamination due to fecal bacteria in the soil can occur as much as 100 feet from the feeding site. Although bacteria levels did decrease after cattle removal from the sites, bacterial concentrations remained greater in July, when samples were taken at 10 feet from the feeders, compared with the other distances.

Soil Nutrient Analysis

Producers fed all feed and mineral supplements well outside the 100-foot range from the bale feeders. In addition, because of the producers' management practices, the type and amount of supplementation differed among sites. We do not believe, however, that feed and mineral supplementation impacted the soil-nutrient analysis data in this experiment.

The greatest concentration of soil phosphorus at 10 feet was recorded in April, the final month of feeding, and concentrations exceeded ($P<0.02$) those in January, February, and May (Table 2). Although there were changes in phosphorus concentrations observed at 10 feet from the feeder, there were no significant differences $P>0.05$) in concentrations observed at 40, 70, or 100 feet from the feeding area. There were linear increases ($P<0.02$) in soil phosphorus concentrations in March, April, June, and July as distance from the feeder decreased.

Concentration of soil nitrogen at 10 feet from the feeding area peaked in July at 70 ppm, and was greater ($P<0.01$) than in all other months except June. At 40 and 70 feet, the greatest concentration of nitrogen was in March, being greater ($P<0.03$) than concentrations in the final three months of the study when cattle had been removed from the sites. There was a quadratic increase ($P<0.02$) in nitrogen concentration in the soil in June and July as distance from the feeder decreased.

Soil sulfur concentrations at 10 and 40 feet from the feeder were greater ($P<0.05$) in March and February than in any other month at every distance in the study. Sulfur concentrations at 70 and 100 feet from the feeder were not different during the experiment. There was a quadratic increase ($P<0.01$) for March, April, June, and July, and linear increases ($P<0.04$) for February and May in soil sulfur concentrations as distance from the feeder decreased.

Soil zinc concentrations at all distances from the feeding area were greater ($P<0.02$) in July than in all other months. There were linear increases ($P<0.05$) in zinc concentrations in March, June, and July as samples were taken closer to the feeder.

Concentrations of soil copper at 10 feet from the feeding area was greatest in June, with the concentration being similar to the concentration in July, and greater ($P<0.01$) than in all other months in the study. At 40 feet from the feeder, the concentration of copper was the greatest in February, which was greater ($P<0.01$) than both January and July. Copper concentrations at 70 and 100 feet in February and April were greater ($P<0.05$) than concentrations in the pre-feeding period (January) of the study. There was a quadratic increase ($P<0.03$) in soil copper concentrations from March to July, as distance from the feeding area decreased.

For soil nutrients, the greatest increase generally occurred at 10 feet from the feeders, with few differences thereafter.

Similar concentrations of organic matter were present at 10, 40, 70 and 100 feet from the feeder in January. From February to May, the greatest concentration of organic matter was observed at 10 feet from the feeder because of a build-up of waste hay and manure. A linear increase ($P<0.02$) in organic matter occurred in March and June as distance from the feeder decreased, whereas a quadratic increase ($P<0.02$) was seen in April.

After cattle access to the sites in February, dry matter of the soil was consistently less for samples taken at 10 feet from the feeder than for those taken at the other distances. There were quadratic decreases ($P<0.02$) in dry matter in March, April, and July as distance from the feeding area decreased, whereas linear decreases ($P<0.01$) were observed in May and June.

Producers should adopt management practices that allow for the removal of manure, wasted feed, or bedding after cattle departure from feeding sites to reduce future environmental impacts.

Table 1. Influence of Time and Distance on Soil Bacteria Concentrations from Round Bale Feeding Sites[a]

	Month[b]							
Item	1	2	3	4	5	6	7	SED
Fecal Coliforms	------------------------			log10 CFU/gram			------------------------	
10 feet	0[c]	0.66[cd]	3.38[f]	3.68[f]	3.02[f]	1.51[e]	0.77[de]	0.40
40 feet	0.11[c]	0.21[c]	1.89[d]	2.32[d]	1.61[d]	0.42[c]	0[c]	
70 feet	0.41[c]	0.16[c]	0.68[cd]	2.38[e]	1.40[d]	0.40[c]	0[c]	
100 feet	0[c]	0[c]	0.47[cd]	2.17[e]	0.83[d]	0[c]	0[c]	
Probability (P<)								
Linear	0.60	0.04	0.0001	0.004	0.0001	0.001	0.01	
Quadratic	0.05	0.50	0.03	0.07	0.20	0.19	0.04	
SED	0.12	0.21	0.31	0.45	0.36	0.30	0.19	
Fecal *E. coli*	------------------------			log10 CFU/gram			------------------------	
10 feet	0[c]	0.45[c]	3.36[ef]	3.67[f]	2.67[e]	1.49[d]	0.69[c]	0.38
40 feet	0.11[c]	0[c]	1.73[de]	2.25[e]	1.40[d]	0.41[c]	0[c]	
70 feet	0.11[c]	0[c]	0.68[cd]	2.32[e]	1.16[d]	0.40[c]	0[c]	
100 feet	0[c]	0[c]	0.30[c]	2.14[d]	0.65[c]	0[c]	0[c]	
Probability (P<)								
Linear	1.00	0.06	0.0001	0.004	0.0001	0.001	0.02	
Quadratic	0.17	0.15	0.03	0.06	0.20	0.20	0.07	
SED	0.08	0.15	0.32	0.45	0.35	0.30	0.18	
Fecal *Streptococci*	------------------------			log10 CFU/gram			------------------------	
10 feet	0.85[c]	2.80[d]	3.82[e]	4.12[e]	2.67[d]	1.14[c]	2.53[d]	0.41
40 feet	0.32[c]	1.57[d]	2.65[e]	2.26[de]	1.90[de]	0.58[c]	1.83[d]	
70 feet	0.36[c]	0.83[cd]	1.79[e]	2.02[e]	2.10[e]	0.82[cd]	1.41[de]	
100 feet	0.17[c]	1.11[de]	0.97[cde]	1.67[ef]	1.60[ef]	0.42[cd]	1.93[f]	
Probability (P<)								
Linear	0.02	0.0001	0.0001	0.0001	0.06	0.09	0.03	
Quadratic	0.35	0.004	0.42	0.01	0.69	0.73	0.01	
SED	0.22	0.28	0.23	0.27	0.39	0.33	0.31	

[a]Soil samples were taken at distances of from 10, 40, 70 and 100 feet from each round bale feeder.
[b]Month 1 = January (before feeding); Months 2 to 4 = February, March, April (feeding period); and Months 5 to 7 = May, June, July (post-feeding period).
[cdef]Means in the same row not having the same superscript letter differ (P<0.05).

Table 2. Influence of Time and Distance on Soil Nutrient Concentrations From Round Bale Feeding Sites[a]

	Month[b]							
Item	1	2	3	4	5	6	7	SED
Phosphorus, ppm								
10 feet	64[c]	66[c]	122[de]	154[e]	93[cd]	129[de]	129[de]	25
40 feet	41	83	59	63	64	53	66	
70 feet	38	39	47	58	71	45	46	
100 feet	45	48	55	53	54	39	53	
Probability (P<)								
Linear	0.39	0.27	0.02	0.003	0.15	0.01	0.02	
Quadratic	0.35	0.82	0.08	0.06	0.72	0.14	0.11	
SED	20	25	25	26	21	29	26	
Nitrogen, ppm								
10 feet	31[c]	24[c]	27[c]	9[d]	26[c]	53[e]	70[e]	9.0
40 feet	23[c]	33[cd]	48[d]	34[cd]	21[c]	22[c]	28[c]	
70 feet	30[cd]	30[cd]	47[d]	19[c]	25[c]	17[c]	26[c]	
100 feet	28	27	30	26	16	19	26	
Probability (P<)								
Linear	0.99	0.83	0.83	0.14	0.46	0.0002	0.002	
Quadratic	0.46	0.35	0.008	0.10	0.83	0.004	0.02	
SED	6.2	8.0	8.6	6.6	8.2	6.1	10.2	
Sulfur, ppm								
10 feet	12[c]	28[d]	73[f]	43[de]	37[de]	41[de]	45[e]	8.0
40 feet	6[c]	26[d]	10[c]	12[cd]	11[cd]	7[c]	9[c]	
70 feet	6	7	8	8	17	9	6	
100 feet	12	9	9	8	7	12	8	
Probability (P<)								
Linear	0.98	0.04	0.0001	0.0001	0.01	0.0003	0.001	
Quadratic	0.05	0.82	0.0003	0.0001	0.25	0.0004	0.01	
SED	4.1	8.1	8.0	4.2	6.6	5.0	6.9	
Zinc, ppm								
10 feet	4.5[c]	4.6[c]	6.4[de]	6.0[d]	5.6[cd]	5.9[d]	7.4[e]	0.65
40 feet	4.1[c]	5.0[cd]	5.3[cd]	5.6[de]	6.0[de]	5.2[cd]	6.8[e]	
70 feet	4.0[c]	4.2[cd]	5.2[cdef]	6.1[f]	5.4[def]	4.7[cde]	5.7[ef]	
100 feet	3.6[c]	4.0[cde]	4.9[def]	5.2[def]	5.2[ef]	3.9[cd]	5.9[f]	

Table 2. Continued

Probability (P<)								
Linear	0.16	0.28	0.004	0.28	0.21	0.02	0.05	
Quadratic	0.95	0.54	0.23	0.60	0.40	0.97	0.55	
SED	0.50	0.63	0.64	0.88	0.58	0.79	0.82	
Copper, ppm								
10 feet	1.35^{c}	1.46^{cd}	1.69^{d}	2.20^{e}	2.10^{e}	2.70^{f}	2.67^{f}	0.13
40 feet	1.20^{cd}	1.52^{e}	1.40^{de}	1.44^{de}	1.23^{cd}	1.43^{de}	1.15^{c}	
70 feet	1.16^{c}	1.41^{e}	1.34^{cde}	1.41^{de}	1.31^{cde}	1.39^{cde}	1.22^{cde}	
100 feet	1.14^{c}	1.44^{e}	1.38^{cde}	1.44^{e}	1.18^{cd}	1.40^{de}	1.25^{cde}	
Probability (P<)								
Linear	0.06	0.61	0.005	0.0001	0.0002	0.0001	0.0001	
Quadratic	0.39	0.88	0.03	0.0001	0.01	0.0001	0.0001	
SED	0.15	0.16	0.16	0.18	0.19	0.13	0.16	
Organic Matter, %								
10 feet	5.23^{c}	5.85^{cd}	7.18^{e}	6.37^{de}	5.97^{cde}	6.36^{de}	6.73^{de}	0.46
40 feet	5.49^{cd}	5.51^{cd}	6.03^{d}	4.69^{c}	5.54^{cd}	5.60^{d}	7.12^{e}	
70 feet	5.51^{cd}	5.23^{d}	6.16^{c}	4.76^{d}	5.29^{cd}	5.40^{cd}	6.59^{e}	
100 feet	5.44^{cd}	5.43^{cd}	5.95^{ce}	4.75^{d}	5.71^{ce}	5.12^{cd}	6.55^{e}	
Probability (P<)								
Linear	0.54	0.37	0.01	0.003	0.37	0.02	0.46	
Quadratic	0.48	0.48	0.09	0.02	0.11	0.54	0.50	
SED	0.42	0.43	0.42	0.44	0.41	0.40	0.38	
Dry Matter, %								
10 feet	83.9^{c}	79.1^{de}	77.0^{ef}	75.7^{f}	74.6^{f}	78.8^{de}	79.7^{d}	1.4
40 feet	84.1^{c}	80.3^{d}	82.4^{cd}	81.3^{d}	81.5^{cd}	81.8^{cd}	87.4^{e}	
70 feet	84.1^{c}	80.9^{d}	82.6^{cd}	81.5^{cd}	80.8^{d}	82.7^{cd}	88.0^{e}	
100 feet	83.7^{c}	81.0^{d}	83.2^{cd}	81.8^{cd}	81.6^{cd}	83.8^{c}	88.1^{e}	
Probability (P<)								
Linear	0.78	0.10	0.0003	0.0001	0.01	0.002	0.0001	
Quadratic	0.60	0.52	0.02	0.0006	0.06	0.38	0.0001	
SED	0.84	1.10	1.14	1.09	1.58	1.05	1.32	

[a]Soil samples were taken at distances of 10, 40, 70, and 100 feet from each round bale feeder.
[b]Month 1 = January (before feeding); Months 2 to 4 = February, March, April (feeding period); and Months 5 to 7 = May, June, July (post-feeding period).
[cdef]Means in the same row not have the same superscript letter differ (P<0.05).