Evaluation of Biochar on Nutrient Loss from Fresh Cattle Manure

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Summary with Implications

An experiment was conducted to evaluate the impact of biochar and time on manure nutrient retention. Pans were used to simulate feedlot pens with 10 replications per treatment. Biochar was included at 0, 5, or 10% of manure dry matter with 30 and 60 day durations to evaluate pan contents over time. There was a 13-percentage unit increase in organic matter losses from day 30 to 60 for pans without biochar, and a 3-percentage unit increase for pans containing biochar. The least nitrogen loss was measured on the pans without biochar harvested at 30 days. Pans harvested at 60 days all had similar nitrogen loss. Phosphorus losses were not impacted by treatment while potassium losses decreased over time but were not impacted by biochar treatment. In this study biochar included at 5 and 10% of manure dry matter limited carbon losses but did not impact manure nutrient retention of nitrogen, phosphorus, or potassium.

Introduction

Biochar has been utilized as a soil amendment to improve soil nutrient content and crop-yield potential for many years. Biochar is produced by burning organic matter (OM; typically plant material) at high temperatures in the absence of oxygen and has vast applications. Recent studies have shown that when biochar is combined with livestock manure, manure nutrient retention (primarily in the form of nitrogen; N) is enhanced. Nutrient losses from feedlot manure, primarily ammonia, are both an environmental and economic concern. Retaining manure N and phosphorus (P) improves the value of manure for the producer when marketed as fertilizer. If excess nutrients in livestock manure are not retained, losses create challenges for air and water quality.

The objective of this study was to determine the impact of varying inclusions of biochar, when combined with feedlot soil and cattle manure, on manure nutrient retention and organic matter losses over time.

Procedure

A simulated feedlot pen study was conducted using 60 aluminum pans (10 × 9 × 2 inches) to represent the hard interface of a feedlot pen. Each pan was weighed and filled with a 60:40 blend of feedlot top soil and manure, respectively. Biochar was included at 0, 5, and 10% of manure dry matter (DM), and all contents of the pan were mixed to mimic the hoof action of cattle in a feedlot pen. A 3 × 2 factorial design was utilized, with biochar inclusion at 0, 5, or 10% of manure DM and samples harvested at 30 and 60 days with 10 replications per treatment. All pans were randomized onto 2 screened, metal shelving units located in a temperature-controlled room in the University of Nebraska-Lincoln Metabolism Lab (Lincoln, NE). Biochar, manure, and soil samples were analyzed for DM and nutrient content prior to study initiation.

Biochar was provided by High Plains Biochar (Laramie, WY) and was sourced from forest wood waste, primarily ponderosa pine trees. Biochar had a DM content of 97.5%, and on a DM basis carbon (C) content was 75.4%, with a surface area of 306 m^2/g, bulk density of 8.1 lb/ft^3, and pH of 8.45. Biochar particle size measured ≤ 2-mm for 72.3% of total sample, 22.7% of sample measured between 2- and 4-mm and the remainder measured >4-mm. Manure was sourced from a commercial feedlot near Mead, NE, that houses cattle in covered pens with slatted flooring. Slatted flooring allows for elevated manure and urine capture, with no soil contamination, therefore, producing a liquified manure slurry. Nutrient content of manure at a DM of 10.4% measured 72.8% OM, 5.87% N, 1.33% P, and 2.66% potassium (K) on a DM basis.

Original intent was to harvest thirty pans at 30 days after trial initiation and thirty pans at 60 days. Due to UNL research restrictions onset from COVID-19, thirty pans selected for harvest at 30-d were placed in plastic bags (to avoid cross-contamination), placed in a freezer, and were ground at a later date. Thirty pans selected for 60-d harvest, were harvested on d 52 of study and ground immediately, due to Phase 4 restrictions on UNL research.

At time of harvest, pans were weighed, and contents were ground through a 1-mm screen. Ground samples were sent to Ward Laboratories, Inc. (Kearney, NE), and analyzed for DM, OM, and nutrient (N, P, K specifically) content. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pan as the experimental unit.

Results

Nutrient losses from the manure:soil mixture are reported as a % of nutrients weighed into each pan on day 1 (Table 1). There was an interaction ($P = 0.05$) between biochar inclusion and day for OM loss. At the 30-day harvest there were no differences between treatments (9.12% OM loss). The biochar treatment was effective at limiting OM losses at 60 days, with the 10% biochar treatment being most effective. The pans with no biochar had an increase in OM losses of 13-percentage units from day 30 to day 60 while the pans with biochar had a 3-percentage unit increase.

A biochar inclusion by day interaction ($P < 0.01$) was observed for nitrogen losses. With no biochar, N losses increased 7 percentage units from day 30 to day 60. With biochar inclusion (both the 5 and 10% biochar treatments) N losses did not increase from day 30 to day 60. The least N loss was measured on the 0% biochar pans harvested

Table 1. Simple effects of biochar inclusion and time on manure nutrient loss

	Biochar 0%		Biochar 5%		Biochar 10%			*P*-Value		
	30d	60d	30d	60d	30d	60d	SEM	Inclusion	Day	Inclusion × Day
OM lost, %	7.50[b]	20.6[a]	9.94[b]	14.0[ab]	9.91[b]	11.8[b]	2.38	0.40	<0.01	0.05
N lost, %	26.3[b]	33.3[a]	34.8[a]	32.7[a]	37.9[a]	33.2[a]	1.85	0.01	0.96	<0.01
P lost, %	3.16	4.75	8.25	4.00	9.75	5.94	2.93	0.42	0.37	0.54
K lost, %	6.36[ab]	1.26[bc]	10.6[a]	0.22[c]	9.34[a]	3.06[bc]	2.15	0.53	<0.01	0.44

[abc]Within a row, least squares means without a common superscript differ ($P \leq 0.05$).

at day 30 while the greatest N losses were for 10% biochar pans harvested at day 30.

Phosphorus losses were not impacted by treatment ($P \geq 0.37$) and averaged 5.98%. There was an effect of day for K ($P < 0.01$) with pans harvested at 30 d having greater K losses compared to pans harvested at 60 d. Biochar inclusion did not impact K losses ($P = 0.53$). The quantities and losses of both P and K were small and there is a challenge in accurately measuring these small quantities.

Results from this study suggest that biochar, included at 5 or 10% of manure DM content, is not a sufficient method to improve nutrient capture from cattle manure. These results are dissimilar to previous literature on the use of biochar inclusion to capture manure nutrients although previous studies focused on manure from animals other than cattle. One primary difference in this study is that manure was collected from covered feedlot pens with slatted floors, thus DM content of the manure was less than 20% and N content was over 5% of DM. Increasing the amount of biochar added may impact the results but could also become expensive, depending on the type and source of biochar.

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