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Nutrient Balance of Nitrogen, Organic Matter, Phosphorus and Sulfur in the Feedlot

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Decreasing protein and phosphorus intake to requirements predicted by 1996 NRC maintained animal performance, decreased nitrogen and phosphorus excretion, and improved waste characteristics.

Summary

Ninety-six crossbred yearling steers (656 lb) were assigned to either control (CON) or balanced (BAL) treatments. Steers were fed for 135 days in 12 waste-management pens with runoff collection basins. Control diet consisted of a DRC, 7.5 % roughage finisher formulated for 13.5 % protein and 0.35 % phosphorus. Balanced diet was formulated using the 1996 NRC model to meet the animal's protein (11.5%) and phosphorus (0.22%) requirements. Gains were unaffected and feed efficiency tended to improve by feeding the BAL diet. Nitrogen and P excretion were lower with BAL steers compared with CON steers. Consequently, the manure's N:P ratio was improved relative to crop needs from 1.9:1 to 3:1 for CON and BAL treatments respectively. Feeding at the animal's requirement for protein and P decreases N and P excretion and improves waste characteristics without compromising animal performance.

Introduction

With the concentration of the feedlot industry into fewer acres and fewer producers, waste management is becoming an increasingly important issue. Feedlot design has advanced to handle the nutrient concentration in these feedlots, particularly surface runoff and leaching. From a cost perspective, minimizing total manure production and decreasing removal time is advantageous. Since manure should be used as a crop fertilizer in feedlot areas, concentration of nitrogen (N) and phosphorus (P) is critical, as crops require a 5:1 N to P ratio.

When manure is used as a fertilizer, either excess P is applied to the land base or extra N needs to be applied to optimize crop yields, since manure typically contains a 2:1 N to P ratio or less. The reason the ratio is typically much lower than 5:1 is partially due to 50 - 70 % of the N volatilizing from the pen after excretion. Phosphorus does not volatilize. Increasing N or decreasing P will add value to the manure relative to crop needs. From a land base requirement perspective, decreasing total N and P excretion would be the most advantageous.

In 1996, the NRC beef committee adopted the metabolizable protein system for evaluation of animal requirements. This system allows nutritionists to match dietary inputs with requirements more accurately than the previous crude protein system.

The objective of this study was to determine effects of minimizing overfeeding of protein and phosphorus on waste management in the feedlot.

Procedure

Ninety-six crossbred yearlings (BW = 656 lb) were used in 12 waste management pens (8 hd/pen). Soil in pens was core sampled (0 to 6 inches) before the trial to estimate nutrient concentration on the pen surface. The animals were then fed for 135 days and pens cleaned after the trial. Manure was sampled during removal and pen soil samples collected to estimate nutrient balance. Soil sampling allows adjustment for inevitable cleaning differences between pens. The pens also contained runoff collection basins to determine total runoff from pens on different treatments. Due to pen design, two pens drain into one pond; therefore dietary treatments were assigned in blocks of two pens. All samples including feed and feed refusals were analyzed for N, OM, P and S.

Two dietary treatments included the control ration (CON), 13.5 % protein and 0.354 % P, and balanced ration (BAL) which minimized protein and P fed to meet, and not exceed, the requirements predicted by the 1996 NRC, 11.5 % protein and 0.22 % P. Control ration included (DM-basis): 81.3 % dry-rolled corn (DRC), 7.5 % alfalfa, 6.2 % molasses with urea and 5.0 % dry supplement. Balanced ration included: 61.4 to 67.4 % high-moisture corn (HMC), 17.2 to 23.1 % corn bran, 7.5 % alfalfa, 3.0 % fat and 5.0 % supplement. Since HMC replaced DRC in the balanced ration, more protein was rumen degradable; therefore less urea was needed to meet the degradable intake protein (DIP) requirement. Corn bran was also added to decrease the P level to the predicted requirement. Three rations were fed in steps with increasing levels of corn bran since the P required decreases with time on feed.

Results

Animal weights, gains and efficiencies were similar between CON and BAL steers (Table 1). Dry matter intake and organic matter (OM) intake were greater ($P<.01$) for CON fed steers. Since BAL contained corn bran to lower P intake, OM excretion was increased

Table 1. Performance of yearling steers by treatment.

	Treatment			
Item	Control	Balanced	SE	P<
Initial weight	652	660	2.8	.12
Final weight	1249	1249	9.8	.99
DM Intake	26.2	25.0	.2	.01
ADG	4.06	4.01	.06	.60
Feed/gain[a]	6.45	6.21		.15

[a]Analyzed as gain to feed, the reciprocal of feed to gain.

Table 2. Organic matter (OM) and nitrogen (N) balance.

	Organic matter				Nitrogen			
Item	Control	Balanced	SE	P <	Control	Balanced	SE	P <
(lbs/hd/day)								
Input	25.2	23.3	.21	.01	0.56	0.47	.004	.001
Retention[a]					0.06	0.06	.0005	.26
Excretion[b,c]	5.15	7.16	.06	.001	0.50	0.42	.004	.001
(lbs/hd)								
Excreted	703	941	7.8	.001	66.3	54.6	.56	.001
Manure	242	404	9.6	.001	12.6	19.7	.52	.001
Soil[d]	7.9	-86	22.6	.05	2.07	-2.83	1.66	.10
Runoff	61	47	6.2	.20	2.47	2.07	.29	.40
Volatilized[e]	393	576	28.8	.01	49.2	35.7	1.77	.01
% volatilized	56	61			74	65		

[a]N retention based on ADG, NRC equation for retained energy and retained protein.
[b]OM excretion calculated as 20.7 % indigestibility for control and 29.9 % for balanced.
[c]N excretion calculated as intake minus retention.
[d]Soil value is from core balance on pen surface before and after trial; negative values suggest removal of nutrient present before trial.
[e]Volatilized calculated as excretion minus manure minus soil minus runoff.

Table 3. Phosphorus (P) and sulfur (S) balance.

	Phosphorus				Sulfur			
Item	Control	Balanced	SE	P <	Control	Balanced	SE	P <
(lbs/hd)								
Intake	12.52	7.90	.08	.001	6.46	5.23	.04	.001
Retention[a,b]	2.05	2.03	.02	.30	0.51	0.50	.004	.27
Excreted[c]	10.47	5.87	.07	.001	5.96	4.73	.04	.001
Manure	6.77	6.49	.28	.50	3.41	5.48	.29	.01
Soil[d]	-1.25	-2.99	.78	.20	-0.13	-3.61	1.17	.10
Runoff	1.75	1.49	.08	.10	2.37	2.33	.24	.90
Difference[e]	3.21	0.89	.86	.12	0.30	0.53	1.22	.90

[a]P retention based on NRC retained protein, 3.9 g / 100 g protein gain.
[b]S retention based on NRC requirement for sulfur amino acids, 4 g SAA / 100 g protein gain.
[c]P and S excretion calculated as intake minus retention.
[d]Soil value is from core balance on pen surface before and after trial; negative values suggest removal of nutrient present before trial.
[e]P and S difference calculated as excretion minus manure minus soil minus runoff.

(P<.01) compared with CON (Table 2). Organic matter removed in manure was increased in BAL pens, due to more excreted and more removed from pen surface. Estimates of OM volatilization or loss was 393 lbs/hd for CON and 576 lbs/hd for BAL. When expressed as percent volatilization, approximately the same amount of OM was lost from each treatment, 56 % and 61 % for CON and BAL pens, respectively.

Nitrogen intake was reduced with BAL treatment (Table 2). Since animal performance was similar, retained protein and N were similar, leading to less N excretion by BAL steers than CON steers. More N was removed from BAL pens, even though N excretion was less. Since more OM was excreted due to the corn bran, more N was trapped on the pen surface with the BAL treatment as compared to CON. This is shown in percentage of excreted N volatilized as ammonia, which was 65.4% for BAL pens compared to 74.2 % for CON pens.

Phosphorus intake was reduced from 12.5 lbs/hd to 7.9 lbs/hd for the 135-day trial for both diets (Table 3). The reduced intake leads directly to a reduction in P excretion, since retention is dependent on retained protein and gain. Similar amounts of P were removed at cleaning from both diets. The BAL cattle excreted less P, suggesting P removed in manure should also be less; however, more P was removed from the pen than was present at the start of the trial, illustrated by the soil core balance. Since P is not volatile, the P not accounted for suggests discrepancies exist between samples and what is either on the soil surface of the pen or in the manure at cleaning.

Sulfur intake and excretion were reduced (P<.01) for BAL steers compared to CON (Table 3). However, more S was removed in the manure than was excreted in the BAL pens. The core balances suggest more OM, N, P and S were removed at cleaning than were present before the trial in BAL pens. Less than 5 % of excreted S in CON pens and 11 % in BAL pens was presumably volatilized, suggesting total reduced sulfur and other volatile sulfur compounds are not significant.

Reducing protein and phosphorus levels maintained animal performance and decreased N and P excretion. The increase in OM excretion did allow more OM and N to be removed even though N excretion was reduced. The N:P ratio in the manure was increased from 1.9:1 to 3:1 for CON and BAL treatments respectively.

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