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Summary of Manure Amounts, Characteristics, and Nitrogen Mass Balance for Open Feedlot Pens in Summer Compared to Winter

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Summary

Data from 18 experiments (244 pen means) over a 10-year period were summarized in order to make a long term comparison between seasons dealing with nutrient mass balance studies and characteristics and amount of manure from open feedlot pens. The amount of manure DM increased from 10.6 lb to 20.0 lb/head finished/day from summer (May to September) to winter (November to May). Quantities of OM, ash, and N (lb/head finished/day) increased from 2.5 lb OM, 8.1 lb ash, and 0.13 lb N to 4.8 lb OM, 15.2 lb ash, and 0.22 lb N/head finished/day from summer to winter, respectively. Summer pens averaged 2.7% of N excretion in pen runoff N, and 6.2% of OM excretion in pen runoff, while winter pens averaged 1.8% of N excretion in pen runoff N, and 1.9% of OM excretion in pen runoff. Average N volatilization was higher for summer feeding pens (69%) compared to winter (47%). The implications, which can be used in individualized NMPs, are more total manure and manure N must be handled, but less volatilization of N and less N runoff occur in the winter compared to the summer feeding period.

Introduction

It is important that correct nutrient mass balances and characteristics of manure from open feedlot pens are known, so producers are able to develop accurate and realistic nutrient management plans in compliance with environmental regulations. While individual experiments have been presented, no long-term comparisons have been made across season. Most experiments have not presented manure characteristics or amounts, which is vital information today. The objective of this study was to determine manure amounts, characteristics, and variation between winter and summer feeding periods.

Procedure

Data from 18 experiments over a 10-year period dealing with nutrient mass balance studies in open feedlot pens were summarized. These experiments have been previously reported (*1996 Nebraska Beef Report,* pp. 74-77; *1999 Nebraska Beef Report,* pp.60-63; *2000 Nebraska Beef Report,* pp. 68-71; *2002 Nebraska Beef Report,* pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58; *2004 Nebraska Beef Report, pp.* 61-63; *2004 Nebraska Beef Report, pp* 69-71; *2005 Nebraska Beef Report,* pp. 54-56; *2005 Nebraska Beef Report,* pp. 76-77*).* While nutrient balance data have been presented, manure amounts and characteristics have not been summarized. These 18 experiments were conducted in a series of open pens with manure and runoff measurement capabilities. Soil was core sampled before each trial to estimate nutrient concentration on the pen surface. The animals were fed in those pens over the summer or winter feeding periods (summer feeding period defined as May to September; winter feeding period defined as November to May), after which pens were cleaned. Collected manure was piled on the cement apron and sampled during removal and pen soil samples were again collected to estimate mass nutrient balances after the feeding period. The soil cores from before and after each nutrient balance experiment were used to correct for either manure left in the pen or soil removed at cleaning. Wet manure was weighed at time of removal and samples used to account for nutrients removed in the manure. These pens also contain runoff collection basins to determine runoff from pens on different treatments. Nutrients in runoff were quantified by sampling each runoff event, during measurement of total volume. In all experiments, cattle were fed in pens with 350 ft^2 per steer and pens were sloped approximately 4%.

Nitrogen Mass Balance

Nitrogen intake was calculated using dietary N concentration from the nutrient profile of each diet fed multiplied by DMI. Feed refusals were quantified, composited, and analyzed to correct N intakes. Cattle nutrient retention was calculated according to the retained energy and protein equations established by the National Research Council for beef cattle. Nutrient excreted was calculated by subtracting nutrient retention from nutrient intake.

Mass balance for N was conducted for each pen in the combined studies. Manure N was quantified by multiplying manure N concentration by amount of manure removed (DM) from the pen surface. Net core N was quantified from soil core samples collected before and after each trial. Runoff N was determined from runoff collection basins. Total N volatilized was calculated by subtracting the sum of manure, soil core balance and runoff N from excreted N. Percentage of N volatilized was calculated as N volatilized divided by total N excretion. All N values were expressed on a pound per head finished basis.

Statistical Analyses

Statistical analyses were conducted using Mixed procedures of SAS (2004) to test for effect of season with experiment in the model. The 244 pens across all diet treatments were tested for differences across season, winter or summer.

(Continued on next page)

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Results

The 18 experiments represented 2,038 head of cattle in 244 observations (seasonal = 132 summer and 112 winter pens). Data summarized in Table 1 for summer and winter pens averaged BW = 791 lb and 724 lb, and gained 477 lb and 602 lb over 128 days and 166 days, respectively. The summer trials averaged 24.7 lb DMI, 3.66 lb ADG, and 6.74 F:G, compared to 23.3 lb DMI, 3.65 lb ADG, and 6.34 F:G for the winter feeding period.

Table 2 is a summary of data of manure solids and related nutrient content for the two seasonal feeding periods. The average wet manure amounts increased from summer to winter, from 15.4 lb/head/day up to 32.9 lb/head/day, respectively. Although the average percentage DM decreased from nearly 70% in summer to just over 61% in winter, the DM amount of manure nearly doubled from summer to winter, increasing from 10.6 to 20.0 lb/head/day, respectively. This compares to the commercial study data that indicated an overall average 73% DM , 15.9 lb/head/day average wet manure, and 11.6 lb/head/day DM amount of manure (*2006 Nebraska Beef Report*, pp. 94-97). There was variation in these values indicated by the minimum and maximum range in Table 2. This increase in DM amount of manure harvested seasonally from summer to winter in this study is explained partially by the substantial increase in quantity of soil hauled out of the pen in the manure during the winter feeding period, as reflected in the nearly doubling of quantity of ash from an average of 8.1 lb/head/day to 15.2 lb/head/day from summer to winter periods. This was the result of more moisture in the manure during the winter period and the mixing of soil into the manure as a result of hoof action of the cattle on the wet manure. Additionally, average percentage OM and OM amounts increased from 24.1% and 2.5 lb/head/day to 27.5% and 4.8 lb/head/day, respectively, from summer to winter. The amounts of manure N increased from 0.13 lb N/head/day to 0.22 lb N/head/day, respectively, from summer to winter, corresponding to the increased average amount of manure DM produced seasonally. But, as a percentage of manure, the average concentration of N in the manure decreased from 1.42 % N in the summer feeding period to 1.20% N in the winter period, presumably due to the increased amounts of soil removed in the manure from the winter feeding period. In comparison, the commercial study indicated (*2006 Nebraska Beef Report*, pp. 94-97) an average 27.8% manure OM , 3.2 lb OM/head/day, 1.21% manure N, and 0.14 lb N/head/day in harvested manure.

N mass balance is a critical evaluation in these studies (Table 3). Variation in values is indicated by the minimum and maximum range. Although average N retention was essentially the same during both

Table 1. Performance data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
Days on feed	128	15	87	166	166	17	105	194	
Initial BW, lb	791	9	650	930	724	13	535	902	<0.01
Final BW, lb	1268	4	1126	1361	1326	4	1181	1444	<0.01
DMI, lb	24.7	6	21.8	28.7	23.3	12	18.7	30.0	<0.01
ADG, lb	3.66	9	2.78	4.27	3.65	8	3.00	4.46	0.86
F:G (DMI/ADG)	6.79	8	5.68	8.22	6.39	8	5.24	8.38	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.

Table 2. Manure characteristics data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
Days on feed	128	15	87	166	166	17	105	194	
As-is, lb/head/day	15.0	47	3.5	35.7	31.9	47	6.3	78.1	<0.01
DM, %	69.6	11	47.0	87.1	61.4	17	31.5	76.9	<0.01
DM, lb/head/day	10.4	47	2.5	26.2	19.3	49	4.1	53.6	<0.01
OM, %	24.1	23	9.5	42.1	27.5	37	11.3	52.4	<0.01
OM, lb/head/day	2.46	47	0.6	5.8	4.84	33	0.9	8.4	<0.01
Ash, %	75.9	7	57.9	90.5	72.5	14	47.6	88.8	<0.01
Ash, lb/head/day	7.9	50	2.0	21.1	14.5	59	2.3	47.6	<0.01
N, %	1.42	39	0.53	2.59	1.20	26	0.62	2.02	<0.01
N, lb/head/day	0.13	48	0.03	0.27	0.22	33	0.04	0.36	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.

Table 3. Nitrogen mass balance data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens. Values expressed as lb/head/day.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
N intake	0.52	16	0.31	0.67	0.48	12	0.38	0.61	<0.01
N retain	0.07	33	0.03	0.10	0.06	28	0.03	0.09	0.09
N excreted	0.47	17	0.28	0.58	0.42	11	0.34	0.52	<0.01
N manure[f]	0.13	51	0.01	0.30	0.22	37	0.04	0.41	<0.01
N runoff	0.012	71	0.00	0.038	0.005	104	0.00	0.031	<0.01
N lost	0.32	21	0.14	0.46	0.20	37	0.04	0.32	<0.01
N lost, %[g]	69.0	21	38.2	97.6	47.2	41	10.1	89.0	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.
[f] N manure = sum of N manure and N soil core balance.
[g]N lost = N volatilized to the atmosphere expressed as % of N excreted.

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Table 4. Comparison of average amounts and percentages of runoff nutrients from open beef feedlot pens.

	Summary[a] 18 Expts	Summer[b] Pens	Winter[c] Pens
Pens, n	244	132	112
Cattle, n	2,038	1,142	896
Average days	145	128	166
Runoff gallons, gal/head	939	1202	643
Average precipitation/experiment, in.	10.8	13.8	7.7
Average rain event days, n	35	37	33
N excreted, lb/head finished	64.1	58.9	69.8
Runoff N, lb/head finished	1.33	1.62	1.04
% of N excreted in pen runoff N	2.1%	2.7%	1.5%
N concentration in runoff:			
ppm	169	161	193
lb/ac-in	38	37	44
OM excreted, lb/head finished	734	657	872
Runoff OM, lb/head finished	31.7	40.5	16.2
% of OM excreted in pen runoff OM	4.3%	6.2%	1.9%
OM concentration in runoff:			
ppm	4045	4042	3020
lb/ac-in	916	916	684

[a]Number of pens from which data were collected: Runoff gallons=244; Runoff N=192; Runoff OM=132.
[b]Number of pens from which data were collected: Runoff gallons=132; Runoff N=96; Runoff OM=84.
[c]Number of pens from which data were collected: Runoff gallons=112; Runoff N=96; Runoff OM=48.

seasons (0.07 lb and 0.06 lb N/head/day), average N intake decreased from summer to winter (0.52 lb N/head/day and 0.48 lb N/head/day, respectively), and N excretion decreased from summer to winter feeding periods (0.47 lb N/head/day and 0.42 lb N/head/day, respectively). Average manure N amount increased from summer to winter from 0.13 lb N/head/day to 0.22 lb N/head/day, with a CV of 51%, but average N runoff decreased from summer to winter feeding periods from 0.012 to 0.005 lb N/head/day, respectively, with a CV of 71%. The average amount of N volatilized decreased from summer to winter (0.32 to 0.20 lb N/head/day). Similarly, the percentage N volatilized decreased from 69% in the summer to 47% in the winter, presumably due to warmer temperature in the summer. The 69% N volatilized value is nearly identical to the average value of 70% N loss indicated from data from commercial studies summarized from collection periods across seasons (*2006 Nebraska Beef Report*, pp. 94-97). There was quite a range of values for percent N loss within season, with CV of 21% for summer, and 41% for winter.

Amounts and percentages of N and OM in runoff from pens in all eighteen experiments are shown in Table 4. In the 244 pens summarized for the 18 experiments, the 2038 steers averaged 145 days on feed, excreted 64.1 lb N/head finished, and 734 lb OM/head finished. The average runoff from each pen was 939 gallons/head. The 244 pens averaged 1.3 lb runoff N/head and 31.7 lb runoff OM/head finished. This was an average of 2.1% of N excretion in pen runoff N and 4.3% of OM excretion in pen runoff OM.

In seasonal comparison (Table 4), the steers in summer and winter pens averaged 128 and 166 days on feed, respectively. The summer steers averaged nearly 59 lb N excreted/head finished and the winter steers averaged 70 lb N excreted/head finished. The winter steers excreted more OM than the summer steers (872 lb OM excreted/head finished and 657 lb OM excreted/head finished, respectively). Although the length of the summer feeding periods were less than the winter periods, runoff from the summer pens was nearly double the amount from the winter pens (1202 gal/head compared to 643 gal/head, respectively) reflecting the higher rainfall amount for the summer feeding period. Although the average precipitation per experiment was 10.8 in. occurring in 35 rain event days, the summer pens received nearly twice the average rainfall amounts compared to the winter pens (13.8 in. in 37 rain event days compared to 7.7 in. in 33 rain event days, respectively). The runoff N amount of the summer pens was nearly 60% greater than the winter pens, and averaged 1.62 lb runoff N/head finished and 1.04 lb runoff N/head finished, respectively. This was 2.7% of N excretion and 1.5% of N excretion in pen runoff N amounts, respectively, for summer and winter pens. The summer pens runoff OM amounts averaged 40.5 lb runoff OM/ head finished, while the winter pens averaged 16.2 lb runoff OM/head finished. These amounts were 6.2% and 1.9% of OM excretion for average summer and winter pen runoff OM, respectively.

Although the average gallons of runoff from the winter pens were nearly half the summer amount, the N concentration in runoff from the winter pens was nearly 20% higher than the summer pens (193 ppm N and 161 ppm N, respectively). Overall, the pens in the 18 experiments averaged 169 ppm N concentration in runoff. But, the OM concentration in runoff decreased from winter to summer (75%). The OM concentration of runoff was 3020 ppm OM and 4042 ppm OM in runoff from winter and summer pens, respectively. The pens in the eighteen experiments averaged 4045 ppm OM concentration in runoff.

There are several implications from this study. Nearly twice the manure is produced on a daily basis/head finished in the winter period compared to summer. More total manure must be handled due to more soil (ash) in the manure during the winter period, in addition to a longer average feeding period in the winter compared to summer. There is more volatilization of N in the summer period compared to winter, resulting in higher manure N in the winter period. But, there is more than twice the N runoff in the summer period compared to winter due to increased rainfall amounts during the summer feeding period. These implications can be used in individualized NMPs.

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