EFFECTS OF BEDDING FEEDLOT CATTLE DURING THE WINTER ON PERFORMANCE, CARCASS QUALITY, AND NUTRIENTS IN MANURE

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Introduction
Feeding cattle in North Dakota poses some environmental challenges with wind, snow and cold. Wind fence and shelterbelt protection have been proven to be effective in enhancing performance of feedlot cattle in the Northern Plains (Anderson and Bird, 1993). Crop residues used as bedding can make animals more comfortable, improve performance and net return. (Anderson et al., 2005) Ammonia volatilization from animal manure is considered a major pollution source in the environment. While bedding is important for the comfort of the animals and profitability for northern feeders, it may be more important in reducing ammonia volatilization from animal manure. This paper reviews two research projects that explore the effects of bedding and different bedding materials for feedlot cattle fed during the winter in North Dakota.

Experiment 1
Procedures
This study compared levels of bedding with wheat straw for finishing steer calves during the winter. The bedding treatments were no bedding, modest bedding, and generous bedding (2x modest bedding). Modest bedding was a subjective judgment to keep some straw available for the steers to lay on. Generous bedding was double the amount provided in the modest bedding treatment. Preconditioned steer calves were allotted to the three bedding treatments in late fall of 2001 (n=53) and 2002 (n=54). All pens were identical in size, orientation, and water source each year with approximately 150 square feet of pen space provided per head in year 1 and 250 square feet in year 2 of the study. Steers were fed the same corn-based (6l Mcal NE_g cwt, 13.2% crude protein), finishing diet to appetite. All calves were weighed every 28 days to compare performance during segments of the winter and spring. Steer calves were fed to finish weight with carcass data collected at slaughter. Steers were marketed to Tyson Fresh Meats (Dakota City , NE). Hot carcass weight, fat thickness, percentage kidney, pelvic and heart fat, ribeye muscle area, and USDA quality and yield grades were determined by qualified personnel 48 hours after slaughter.

Straw was added approximately weekly with longer periods between bedding when weather allowed. Big round bales were deposited in the pens and spread throughout the bedding area with a front end loader equipped with a grapple fork. Calves had access from the bedded area to feedbunks and water fountains on concrete aprons.

To evaluate the effects of bedding on manure and fertility values, 8-10 samples of raw manure were collected from each pen and composited by pen prior to analysis. Manure was removed from each pen and placed in a windrow and composted for 2 months until stable. Compost windrows were turned five times at approximately two-week intervals. Sampling was done when the composting process was complete with 8-10 subsamples collected and composited for each respective pen manure windrow.

Results
Feedlot performance
Dry matter intake (Table 1) was not affected by bedding level (P<.05) over the length of the study. Non-bedded steers fluctuated more in feed intake but differences balanced out over the length of the study. Gains responded significantly (P<.05) in two of the four periods and overall. Final weights were greater for both bedded treatments at 1182 and 1172 vs. 1121 lbs. for steers with no bedding. Generously-bedded steers gained 3.53 lbs. per day, modestly-bedded steers gained 3.69, and steers without bedding gained 2.83. Gain per feed improved significantly (P=.06) in one period and overall for bedded steers (P=.09).

Table 1. Effect of amount of bedding on feed intake, gain, and feed efficiency for steers finished in North Dakota during the winter.

Item	Treatment: No bedding	Modest bedding	Generous bedding	Std Err	P value
Initial wt, lbs.	725	726	727	12.2	0.85
Final Wt., lbs.	1121	1172	1182	16.4	0.40
Dry matter intake, lb/hd/d					
Period 1	20.50	19.91	20.74	1.41	0.92
Period 2	22.84	21.59	21.64	1.86	0.87
Period 3	22.51	21.86	22.88	1.45	0.89
Period 4*	22.11	23.43	23.41	1.23	0.72
Overall	21.99	21.96	22.16	1.56	0.99
Avg daily gain lb**					
Period 1	3.16[a]	3.84[b]	3.81[b]	0.05	0.01
Period 2	2.66	3.63	3.81	0.68	0.38
Period 3	2.90[a]	3.67[b]	3.37[b]	0.14	0.03
Period 4*	2.62	3.61	3.16	0.65	0.36
Overall	2.83[a]	3.69[b]	3.53[b]	0.06	0.01
Gain/feed					
Period 1	0.155	0.194	0.184	0.01	0.14
Period 2	0.124	0.170	0.178	0.04	0.48
Period 3	0.130[a]	0.167[b]	0.148[ab]	0.01	0.06
Period 4*	0.116	0.155	0.035	0.03	0.36
Overall	0.131[a]	0.172[b]	0.161[b]	0.01	0.09

* During year 2 in the last weigh period, calves in the "No bedding" treatment were moved to a different pen and given bedding as they were severely stressed by cold and wet conditions and manure tags. Compensatory gains were observed and are included in the data set.

**Actual weight gains may be lower than reported due to higher levels of manure tags on the steers in the no-bedding treatment.

[ab] Values with different superscripts are significantly different (P< 10)

Carcass Quality

Most carcass quality traits (Table 2) were also positively affected by bedding (P<.05). Carcass weight and dressing percent improved with bedding, probably affected by the weight of manure tags on the non-bedded calves. Marbling scores improved with bedding as did the percent of carcasses grading choice. Twenty-three percent of carcasses from steers without bedding graded choice, vs. 45% and 63% for bedded steers. Ribeye area tended to increase (P=.06) with bedding from 11.47 square inches to 12.09, and 11.99, respectively for normal and extra bedding. Yield grade, fat thickness over the 12th rib, and internal fat (kidney, pelvic, heart fat, KPH) were not affected by bedding.

Table 2. Effect of amount of bedding on carcass quality for steers finished in North Dakota during the winter.

	Treatment				
Item	No bedding	Modest bedding	Generous bedding	Std Err	P value
Final weight, lbs.	1121[a]	1182[b]	1172[b]	18.41	0.02
Carcass wt, lbs.	674[a]	715[a]	721[b]	12.86	0.02
Dressing percent	61.95[a]	62.33[ab]	63.43[b]	0.38	0.02
Marbling score*	361[a]	392[b]	415[b]	10.89	0.01
Percent Choice	23	45	63	-	-
Yield grade**	2.98	3.03	3.09	0.07	0.30
Fat thickness, inches***	0.39	0.43	0.46	0.03	0.13
Ribeye area, square in.	11.47[a]	12.09[b]	11.99[b]	0.25	0.06
KPH, %	2.43	2.51	2.43	0.05	0.14

* Marbling score is numeric value based on dispersion of fat inside ribeye muscle, 300-399 = select, 400-499 = low choice. Higher scores = more marbling and higher carcass value

** Yield grade is a measure of fat to lean ratio, 1 = lean, 5 = fat.

*** Measured over 12th rib

[ab] Values with different subscripts are significantly different. (P<10)

Manure Nutrient Analysis and Composition

According to Table 3, there seems to be some differences in the amount of N sequestered in manure based on the amount of wheat straw bedding used in beef feedlot pens. These are not strong trends but worthy of some discussion.

Table 3. Nutrient levels of raw and composted manure at different bedding levels (dry matter basis).

Raw Manure	No bedding	Modest bedding	Generous bedding
N%	1.59	1.55	1.90
P%	0.72	0.65	0.76
NH_4-N ppm	1384	1272	1065
Composted Manure			
N%	0.83	1.40	1.61
P%	0.51	0.75	0.81
NH_4-N ppm	81.2	60.9	64.7

Table 3 shows a trend of increasing total N sequestration in fresh manure with an increasing amount of bedding used per pen. There doesn't seem to be a large difference between no bedding and modest bedding. However, when twice as much bedding was used in the generous bedding compared to the modest bedding, there is a higher amount of total N retained in the fresh manure. This is usually explained by more urine retained as more bedding is used leading to a higher level of NH_4-N in the manure contributing to higher total N, but the amount of NH_4-N does not look different for the treatments. Therefore, some other factor not easily explained is causing the increase in total N retention.

Table 3 also shows a trend of increasing N sequestration in composted manure with an increase in the amount of bedding used per pen. This makes sense since the higher level of total N in the fresh manure carried through to the compost results. The table does show an inverse relationship between NH_4-N levels and bedding levels. This can be explained by the fact that there is a low level of C available in pure beef manure leading to an incomplete compost reaction. The composting process works best with a C:N ratio of 30:1 to 40:1 and beef feedlot manure has a C:N ratio of about 15:1. Because of this incomplete reaction, the compost pile will not heat to very high temperatures thereby burning off less NH_4-N than the other treatments where there was more C available.

The tables show no clear trend in the amount of P retained vs. bedding level whether the manure is fresh or composted. There is a slight trend in increased P retention for composted manure as bedding levels increase. This may be due to the fact that P levels become more concentrated in fully-composted manures and the no-bedding manure was not able to fully compost due to an inappropriate C:N ratio.

Experiment 2

This study was conducted to compare different crop residues as bedding materials for feedlot cattle. The bedding treatments were: 1) No bedding (pens were scraped two times per month), 2) bedding with wheat straw, 3) corn stover, or 4) soybean residue. All bedding materials were harvested with a large round baler. Preconditioned steer calves (n=113) were allotted to four bedding treatments in late fall of 2004. Steers were assigned to one of eight pens with 14-15 head per pen, and two replicates per treatment. All steers were weighed every 28 days.

Steers bedded with wheat straw.

Steers bedded with corn stover.

Steers bedded with soybean residue.

A common corn-based diet formulated to contain 60 MCal NEg/cwt and 13.1% crude protein was fed to all cattle in this study. Feed was delivered as a totally-mixed ration once daily to appetite. Steers were fed in open drylot pens equipped with automatic waterers, and fenceline bunks, which allowed for two feet of bunk space per head. A windbreak shelterbelt was located approximately 100 feet to the north of the pens. All pens were identical in size, orientation (south sloping), and water source with approximately 300 square feet per head.

Steers were bedded approximately weekly or as required considering weather challenges. Bedding was accomplished with a Haybuster Straw Cannon®, a modified bale processor with a blower and "spout" that is capable of blowing bedding into a pen from the feed alley. The spout is mounted to distribute straw into the pen behind the bunkline and was directionally controllable with hydraulics from the tractor cab. In some cases, bales were placed in the pen with a payloader and spread with the bucket and grapple fork. The same number of bales was used in each pen.

Haybuster straw cannon bedding pens from the feed alley.

Steers were marketed to Tyson Fresh Meats (Dakota City, NE) on May 17, 2005. Hot carcass weight, fat thickness, percentage kidney, pelvic and heart fat, ribeye muscle area, and USDA quality and yield grades were determined by qualified personnel 48 hours after slaughter.

Results

Feedlot performance

Calves in this study generally performed very well during the winter with some positive effects due to bedding observed. Month of the year associated with spring thaw and breakup had some negative effects on intake and gain across all treatments, however.

Dry matter intake (Table 4) tended to be lower (P<.12) overall for the calves bedded with corn stover vs. all other treatments. The palatability of stover is well known and calves tend to eat the leaves and husks if available. A modest dilution in the energy density may have contributed to the lower (P<.01) gains for the stover-bedded calves. Dry matter intake was equal for all other treatments over the length of the study. Dry matter intake was lower (P<.06) for bedding treatments compared to control during the first two months on feed. This suggests calves without bedding had greater appetites, and higher maintenance requirements as gains in the control pens were lower for the first three months on feed. During periods 3 and 4, the inverse tended to occur (P<.13) with bedded calves consuming more feed and exhibiting similar or greater gains. Intake during periods 4 and 5 decreased with spring thaw, mud, and challenging temperatures, however, gains seemed to be stable from previous months. In this study, bedding is credited for marketing heavier cattle. Calves bedded with straw gained the fastest (P<.01) followed by soybean residue, stover, and the calves in the scraped control pen (Table 4). Differences in weight gain over several months led to significantly heavier (P<.05) calves in the straw treatment during the last two months of the study, followed by soybean residue, corn stover, and last, no bedding. Feed efficiency was greater for the bedded calves (P=.03 to .11) during the first three months on feed, the coldest part of the winter. No differences were observed for the last two months on feed.

Table 4. Performance of steers bedded with different materials during the winter.

	Treatment					
Item	No Bedding	Wheat Straw	Corn Stover	Soybean Residue	St. Error	P Value
Weight, lbs.						
Dec. 12	652.9	651.9	652.9	652.0	7.96	0.98
Jan. 11	742.7	755.9	751.9	759.4	8.64	0.58
Feb. 10	855.7	875.9	860.8	880.6	9.75	0.25
Mar. 11	973.4	1022.6	991.0	1015.4	11.57	0.19
Apr. 7	1065.0^{a}	1122.2^{b}	1065.8^{a}	1101.5^{ab}	12.20	0.01
May.17	1211.7^{a}	1253.8^{b}	1225.6^{ab}	1243.3^{ab}	14.10	0.05
Dry Matter Intake, lbs.						
Period 1	19.32^{a}	18.47^{b}	18.41^{b}	18.56^{b}	0.17	0.06
Period 2	24.13^{a}	21.44^{b}	21.40^{b}	23.22^{ab}	0.51	0.05
Period 3	21.53	23.35	21.39	22.86	0.51	0.13
Period 4	20.29^{a}	21.81^{b}	20.46^{a}	21.80^{b}	0.40	0.10
Period 5	16.11	16.59	16.19	16.69	0.46	0.77
Overall	20.24	20.30	19.62	20.59	0.21	0.12
Avg. Daily Gain, lb.						
Period 1	3.22^{a}	3.71^{b}	3.52^{ab}	3.84^{b}	0.12	0.01
Period 2	3.77^{a}	4.00^{b}	3.65^{a}	4.04^{b}	0.11	0.04
Period 3	4.06^{a}	5.06^{b}	4.48^{ab}	4.65^{ab}	0.13	0.01
Period 4	3.38^{a}	3.69^{a}	2.78^{b}	3.19^{ab}	0.12	0.01
Period 5	3.66^{ab}	3.30^{b}	3.99^{a}	3.55^{ab}	0.13	0.01
Overall	3.63^{a}	3.91^{b}	3.72^{ab}	3.84^{a}	0.07	0.01
Feed Efficiency (Gain/Feed)						
Period 1	0.165	0.201	0.191	0.207	0.009	0.11
Period 2	0.157^{a}	0.187^{b}	0.171^{ab}	0.174^{ab}	0.004	0.05
Period 3	0.189^{a}	0.217^{b}	0.200^{ab}	0.204^{ab}	0.004	0.03
Period 4	0.167	0.169	0.136	0.146	0.016	0.49
Period 5	0.227	0.196	0.247	0.213	0.013	0.18
Overall	0.179	0.193	0.189	0.187	0.003	0.12

^{ab} values with different superscripts are significantly different (P<10).

Carcass Quality
Yield grade and fat thickness appear to be affected by treatment (P<.02) and patterned after live weight with increased fat deposition in straw-bedded calves followed by soybean residue, control, and corn stover (Table 5). Ribeye area and kidney-pelvic-heart fat were not affected by treatment.

Table 5. Carcass traits for steers bedded with different materials.

	Treatment					
Item	No Bedding	Wheat Straw	Corn Stover	Soybean Residue	Standard Error	P Value
Hot Carcass Wt., lb.	724.3	754.4	734.0	743.1	9.1	0.17
Dressing Percent	62.23	62.69	62.29	62.26	0.002	0.51
Marbling Score*	464	448	430	484	17.2	0.17
Yield Grade**	3.37[a]	3.53[b]	3.22[a]	3.42[b]	0.067	0.02
Fat Thickness, in.	0.55[ab]	0.61[a]	0.49[b]	0.57[ab]	0.02	0.02
Ribeye Area, sq. in.	12.32	12.59	12.43	12.59	0.16	0.60
KPH, percent	2.33	2.44	2.36	2.38	0.04	0.31

* 300 = Select, 400 = Low Choice, 500 = Avg. Choice

** Measure of fat to lean ratio, higher values indicate more fat

[ab] values with different superscripts are significantly different (P<10).

Manure Nutrient Analysis and Composition
According to Table 6, there are definite trends associated with the amount of NH_4-N, Total N and P when comparing fresh or composted manure from pens that used bedding vs. no bedding. The numbers show that these nutrients are more highly sequestered when any bedding source is used vs. no bedding either when analyzed fresh or composted.

Table 6. Nutrient content of raw and composted manure from different bedding materials applied to feedlot cattle on finishing rations during the winter of 2004-2005 at the Carrington Center.

	Treatments			
	No bedding	Wheat Straw	Corn Stover	Soybean Residue
Raw Manure				
Water,%	24.41	70.96	76.45	68.44
Dry Matter, %	75.60	29.05	23.55	31.56
NH_4-N, ppm	829.61	2583.34	4137.75	2890.57
N,%	1.11	2.72	3.88	2.62
P,%	0.26	0.59	0.59	0.45
K,%	0.59	2.48	2.86	2.29
Zn, ppm	51.49	141.22	129.82	105.48
Cu, ppm	8.43	20.58	24.98	20.83
Composted Manure				
Water,%	23.66	45.79	40.88	38.47
Dry Matter, %	76.34	54.21	59.13	61.54
NH_4-N, ppm	1354.40	209.65	1655.08	387.45
N,%	1.31	2.21	2.55	2.62
P,%	0.48	0.81	0.98	0.86
K,%	1.26	2.57	3.20	2.94
Zn, ppm	135.9	176.43	214.2	179.75
Cu, ppm	21.70	27.38	36.73	32.15

When comparing the bedding sources of wheat straw vs. soybean straw vs. corn stover bedding, the corn stover seems to sequester more NH_4-N and total N than the other bedding types when comparing the analysis of the fresh manure. The trend continues with NH_4-N when composted but is non-existent for total N.

The fact that manure with bedding sequesters more nutrients is not surprising. When bedding is utilized, more of the urine should be retained in the pack and the bedding is an enhanced substrate for retaining NH_4-N. The difference in nutrient retention between corn stover and the other bedding sources can also be explained.

From a fresh manure analysis standpoint, corn stover will act more like a sponge than the other bedding sources and retain a higher amount of urine. Urine is the main source of NH_4-N which explains why the corn stover-bedded manure contains nearly twice as much NH_4-N when analyzed fresh.

The reason for higher NH_4-N levels in corn stover vs. the other bedding materials from the composted manure analysis is due to the nature of the composting process. When you compare the C:N ratio of corn stover (65) to wheat (80) and soybean (40) straw, it is in the middle. The C:N ratio of beef manure is 15. For optimum composting a C:N ratio of 30:1 to 40:1 is required. The corn stover bedding mixed with the beef manure probably resulted in a near optimum C:N ratio. With an optimum compost process, there should be less loss of NH_4-N added to the fact that there was nearly twice as much NH_4-

N in the fresh corn-stover bedded manure means that a higher amount of NH_4-N should remain in the material after composting.

The numbers do show that no bedding retains more NH_4-N when composted compared to wheat straw or soybean straw. This also makes sense since there is a low level of C available in pure beef manure leading to an incomplete compost reaction. Because of this incomplete reaction, the compost pile will not heat to very high temperatures thereby burning off less NH_4-N than the other treatments where there was more C available.

For both experiments, data were analyzed using SAS GLM procedures with pen as the experimental unit. Research protocols followed guidelines recommended in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1998). Both projects were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Discussion

Based on Experiment 1 results, if steers are sold on a realtime grid with a $10/cwt break from choice to select cattle, the advantage for modest bedding is $61.76 per head and $81.61 for generous bedding. Several other factors can affect carcass value with different marketing grids and time of the year including Yield Grade, USDA Grade, premium programs, carcass weight, and other traits.

Additional value is captured from the extra nutrients in the manure which is used for fertilizer, either in the raw or composted state. If the cost of N is $0.30/lb and the use of generous bedding can sequester 7 more lbs. of N per ton of fresh manure then a producer can realize $2.10 more N fertilizer value per ton of manure.

The magnitude of improvement in steer performance and net return for bedding is much greater in Experiment 1 than other research reported. In southeastern South Dakota, Birkelo and Lounsbery (1992) observed a positive effect on gain, feed efficiency, and return when using 266 pounds of bedding per head in open lots. A Colorado study (Stanton and Schutz, 1996) also concluded that bedding improves gain and dressing percent in finishing steers but had no impact on feed intake while returning an extra $8.00 per head above costs.

There appear to be some real difference in bedding materials for steers. The commonly held idea that straw is the best bedding material is supported in this study although significant improvement in nutrients in manure is observed with soybean residue and corn stover. Corn stover and soybean residue may be more useful in situations where gain is not critical such as growing heifers and beef cows near calving, and these residues are generally available on a cost-competitive basis.

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