Effects of Bedding Type on Animal Performance, Manure Nitrogen Retention and Composting Efficiency

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Research Summary
Year one results have not demonstrated a significant improvement in the performance of developing heifers when bedding is added to feedlot pens during winter feeding in southwest North Dakota. In addition, no significant differences were found in nutrient content of fresh manure, although potassium levels tended to be higher in bedded treatments. Analysis of composted manure and bedding revealed corn stover and oat straw as the superior bedding sources for nutrient retention.

Introduction
This project was designed to evaluate the effect of five different bedding sources on animal performance and to measure each bedding source's subsequent effect on nutrient binding capacity and composting efficiency. Previous research has shown that bedding improves cattle comfort and performance (Anderson et al., 2001), but there is little information on the use of bedding to capture nutrients from livestock manure. Therefore, it was hypothesized that bedding could serve a dual purpose by providing cattle comfort during inclement weather and absorbing and capturing nutrients that would otherwise be lost to runoff or volatilization. In addition to providing an absorptive material in the pen, organic bedding materials provide the carbon necessary for composting livestock manure. Composting has several benefits including killing weed seeds, concentrating nutrients, reducing volume and when applied to soil, improving drainage, structure, and nutrient holding capacity of all types of soils (Card 2002). Most research to date has studied the quantity of bedding that should be used, when wintering cattle, whereas this project will focus on the impact bedding source has on animal performance, nutrient absorption capacity and the effect differing carbon sources have on efficiency of the composting process.

Material and Methods
One hundred heifers were weighed, blocked by weight, and assigned to the following five treatments: 1) control – no bedding, 2) barley straw, 3) oat straw, 4) corn stover and 5) wheat straw, and wintered for 111 days. Each experimental treatment was replicated four times. Nutrient composition of a common heifer development diet that was fed across treatments is shown in Table 1. Daily feed delivered and ending residual feed weights were recorded and used in feed efficiency computations. Bedding was added to each treatment pen on a weekly basis and heifer body weights were taken at 28-day intervals, and at the conclusion of the study. To evaluate the effect of carbon source on composting, all treatment heifers were removed from the pens and, as soon as weather permitted, bedding packs and pen manure were scraped and piled to begin the composting process. Samples for nutrient analysis were collected immediately and measurements were taken to estimate pile volume. Piles were monitored weekly for changes in temperature and were turned with a front-end loader when the average temperature fell below 120 º F (48.5 º C). Composting was considered completed when pile temperatures continually declined regardless of turning. Once composted, piles were sampled for nutrient analysis and measured to determine final volume.

Table 1. Nutrient composition of diet fed to heifers during bedding trial (dry matter basis).

	Hay	HI-EN 14*
Dry matter, %	88.58	88.51
Crude protein, %	12.55	14
Calcium, %	0.84	0.5
Phosphorus, %	0.26	0.5
Acid detergent fiber, %	44.69	
Neutral detergent fiber, %	63.17	
Total digestible nutrients, %	51.59	
Salt, %		0.25
Vitamin A, IU/lb		4,000
Vitamin D, IU/lb		400
Crude Fat, %		2.5

*** Commercial feed supplement.**

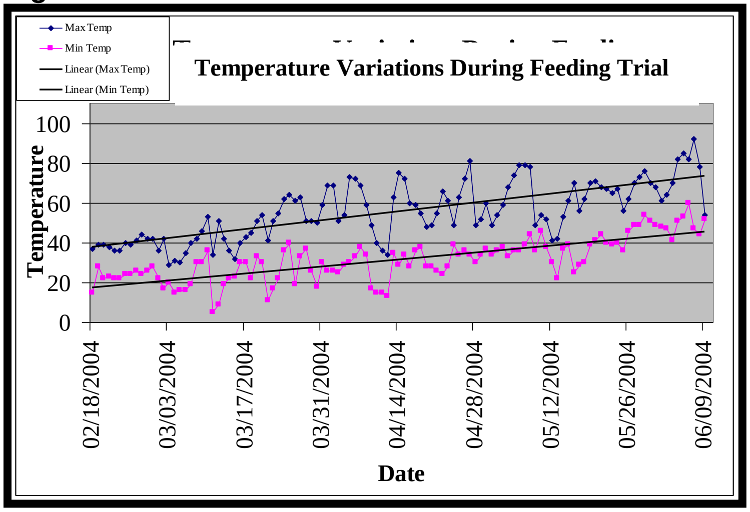
Results and Discussion

No significant difference was found for start weight (P = .9994), end weight (P = .9932), average daily gain (P = .8528) or feed efficiency (P = .8026) among wintered heifers with or without bedding, as shown in Table 2. The timing of the trial, coupled with mild weather and protection from the wind, may have lessened the impact of weather events and the overall effect of the bedding sources on animal performance. Ambient temperature ranges were monitored during the feeding trial and are illustrated in Figure 1.

Table 2. Performance data for heifers in bedding trial. Reported on a pen basis.

	Control	Barley	Oats	Stover	Wheat	P Value
Start Weight, lbs.	3706	3705	3739	3750.5	3736.3	0.9994
End Weight, lbs.	4846.8	4804.6	4890.1	4884.9	4890.37	0.9932
ADG, lbs. /d	2.07	2.00	2.09	2.06	2.10	0.8528
Feed:Gain	10.53	10.52	10.36	10.29	10.05	0.8026

Figure 1.



There were no significant differences in feed intake among treatments. However, heifers in the unbedded control treatment tended to eat more during the second feed period (P = .2041). If bedding was consumed by heifers it was not enough to reduce feed intake. Feed intake values were monitored for each 28-day period and are summarized in Table 3.

Table 3. Feed intake for heifers in bedding trial. Reported on a pen basis.

	Control	Barley	Oats	Stover	Wheat	P Value
Feed – PD 1	2917	2870	2907	2940	2895	0.94
Feed – PD 2	3138	2965	3118	2965	2920	0.20
Feed – PD 3	3183	3039	3163	3110	3025	0.47
Feed – PD 4	2744	2658	2733	2633	2718	0.70
Total Feed	11981	11531	11920	11647	11557	0.39

PD 1, 2, 3, 4 = First, second, third and fourth period.

Heifers were bedded each week with approximately 84 pounds of bedding. The goal was to provide approximately 266 pounds of bedding per head over the feeding period based on findings by Birkelo and Lounsbery (1992). Four weeks after initiation of the project, it was determined that additional bedding was required to create an adequate bedding pack. Sufficient bedding was added to each pen to create a pack and future bedding weights were adjusted to create similar weights among treatments. Heifers received approximately 320 pounds of bedding per head over the feeding period. However, heifers receiving wheat straw had a significantly higher bedding weight than heifers in other treatments. After scraping and piling, manure pile volumes were calculated using three pile measurements taken immediately after piling was completed. A significant difference in pile volume was measured between the unbedded control pens and pens that received bedding. Total bedding weights and volumes are shown in Table 4. Final volume and change in volume were calculated after composting. All bedded treatments decreased in volume where as the unbedded control increased in volume. It is likely that excess soil was added to the piles during the process of turning. In the case of the unbedded control, there was not enough decrease in volume by composting to account for added soil, resulting in increased volume.

Table 4. Bedding weight and pile dimensions for bedding trial.

	Control	Barley	Oats	Stover	Wheat	P Value
Bedding total, lbs.	0.0^{a}	1587.75^{b}	1595.50^{b}	1599.50^{b}	1607.25^{b}	<0.01
Initial Volume, cu in.	435,436^{a}	813,117^{b}	869,452^{b}	826,503^{b}	816,574^{b}	<0.01
Final Volume, cu in.	488,176	596,038	634,442	601,146	655,200	0.38
Change in volume, %	+15.70^{a}	-26.72^{b}	-25.50^{b}	-26.41^{b}	-19.11^{b}	<0.01

^{ab}Values with differing superscripts are significant.

Manure samples collected immediately after piling were sent to the NDSU Soils Lab and analyzed for dry matter (DM), ammonia-nitrogen (NH4), nitrogen (N), phosphorus (P), potassium (K) and organic matter (OM). Manure nutrient analysis results are shown in Table 5. Dry matter was significantly different among treatments. Unbedded control pens had significantly higher dry matter (P = .0114). This can most likely be explained by the lack of absorptive material, resulting in an increase in runoff. Ammonia-nitrogen values for barley and wheat treatments tended (P = .2007) to be higher than other treatments indicating a more stable carbon to nitrogen ratio and reduced nitrogen volatilization. The significantly higher amount of bedding in the wheat treatment may also have contributed to less nitrogen volatilization. Potassium tended (P = .1585) to be higher in the barley-and oat-straw treatments when compared to the unbedded control. No significant differences were found among treatments in percent nitrogen (P = .6098), phosphorus (P = .4371), or organic matter (P = .4277). A difference in organic matter was expected between the unbedded control and bedding treatments, but was not detected. After estimating manure production over the feeding period, the amount of bedding would only account for 2.6 - 3.2% of the total weight of the manure and bedding, making it next to impossible to detect differences in organic matter. Failure to obtain a representative sample may also have contributed to the results. There was a great deal of variation between samples within treatments as shown in Table 6.

Table 5. Manure characteristics of initial manure and bedding pile.

	Control	Barley	Oats	Stover	Wheat	P Value
Dry Matter, %	58.99^{a}	45.01b^{c}	47.61^{bc}	49.15^{bc}	40.46^{c}	0.01
Ammonia-N, ppm	158.15	328.50	288.19	249.50	311.13	0.20
Nitrogen, %	1.23	1.42	1.25	1.48	1.40	0.61
Phosphorus, %	0.39	0.48	0.39	0.42	0.41	0.44
Potassium, %	0.59	0.88	0.81	0.75	0.75	0.16
Organic Matter, %	39.65	46.62	36.00	44.60	43.40	0.43

^{abc}Values with differing superscripts are significant.

Table 6. Variability among manure samples.

Treatment	Mean					Standard Deviation				
	DM	NH4	N	P	K	DM	NH4	N	P	K
Control	0.60	158.15	0.90	0.22	0.33	0.07	128.78	0.48	0.04	0.10
Barley	0.49	328.50	0.63	0.21	0.38	0.08	112.28	0.10	0.04	0.05
Oats	0.52	288.18	0.60	0.19	0.39	0.05	76.32	0.15	0.03	0.09
Stover	0.51	249.50	0.72	0.21	0.37	0.07	89.39	0.06	0.02	0.05
Wheat	0.44	311.13	0.57	0.16	0.30	0.05	103.38	0.09	0.04	0.07

Once initial sampling and measuring of manure piles was completed, piles were moved to a location where they could be monitored and turned until the composting process was completed. Two temperatures were taken from each pile on a weekly basis. Temperature differences became significant three weeks after piling and remained significantly different for four weeks. During the seventh through ninth weeks, temperatures among treatments were similar. Temperature differences became significant during weeks ten and eleven and returned to similar until week seventeen. Throughout the composting period, temperatures of the bedded treatments exceeded those of the control. No one treatment was consistently higher in temperature throughout the entire 17-week monitoring period; however, oat straw had the highest temperature nine out of 17-weeks. Figure 2 shows the compost temperature fluctuations among treatments. Precipitation received during the 165-day composting period totaled 7.55 inches. The largest single-day event occurred on June 12, 2004, when 0.70 inch was recorded. The lack of adequate moisture, high air temperatures, and high dry matter portion of the manure and bedding material explains why the composting process took 165 days. Air temperatures during the composting period can be found in Figure 3.

Figure 2.

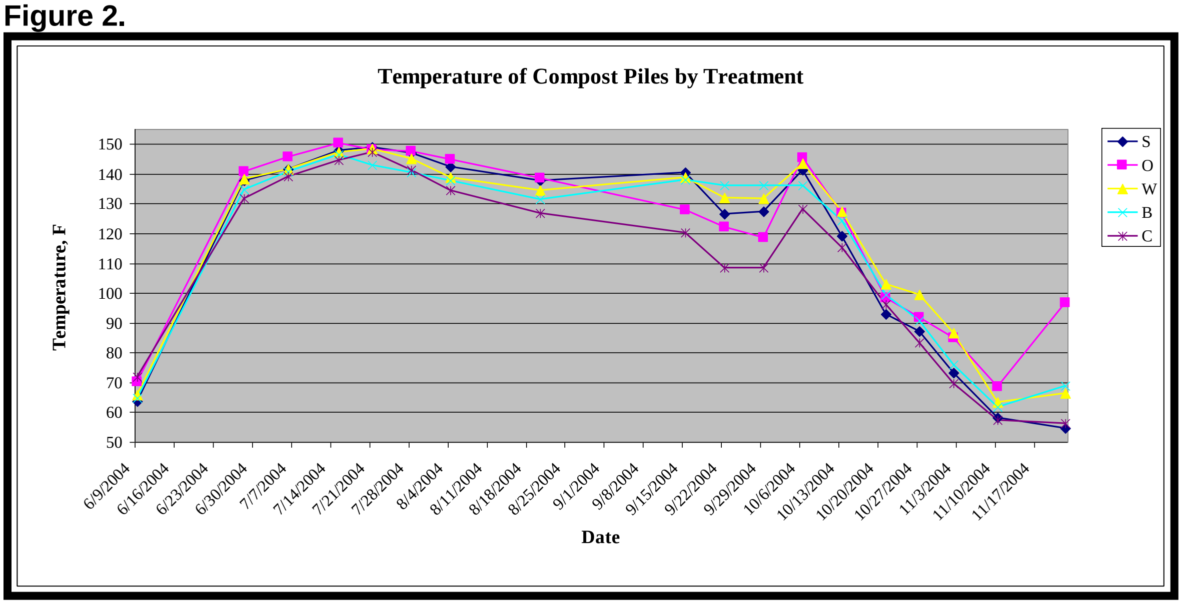
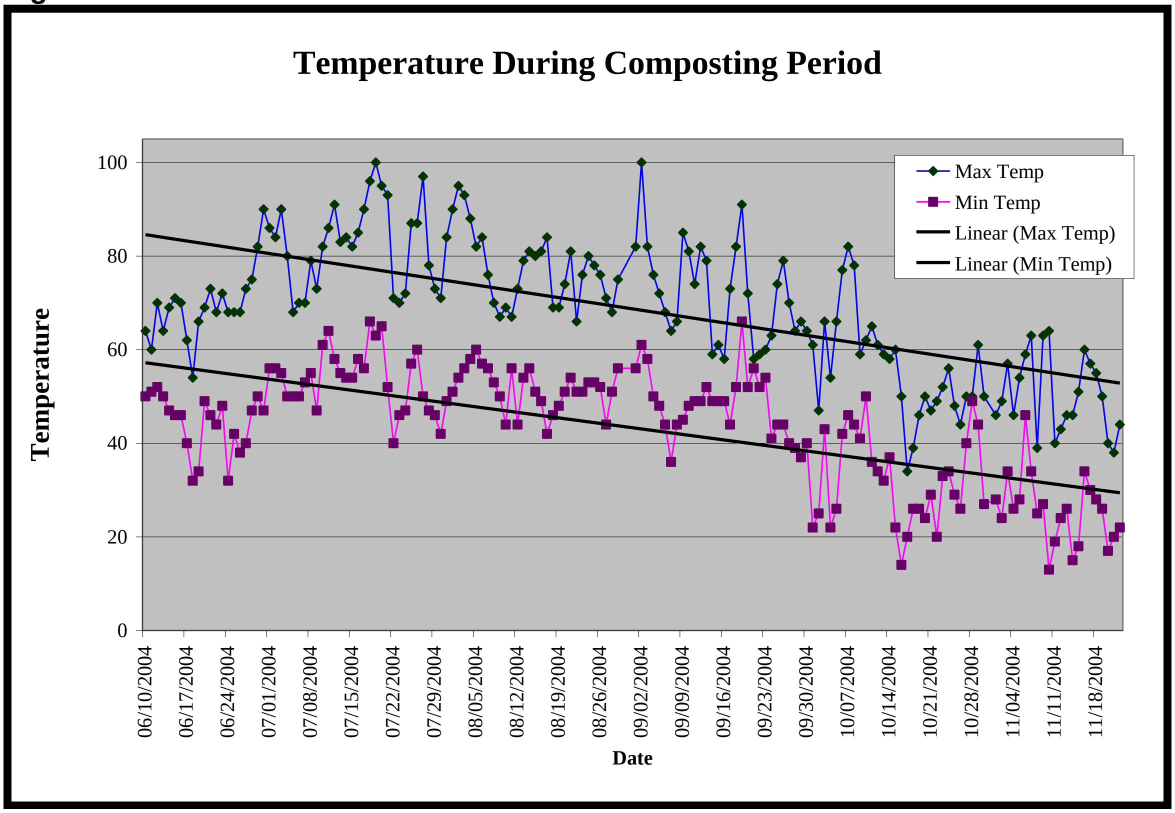


Figure 3.



Compost samples were collected from each of the replicated bedding source piles and were analyzed for dry matter (DM), ammonia-nitrogen (NH4), nitrogen (N), phosphorus (P), and potassium (K) at the NDSU Soils Lab. Compost nutrient levels are summarized in Table 7. Compost dry matter values did not differ (P = .3333) among treatments. The corn stover and oat straw treatments contained significantly more nitrogen than either the barley or wheat straw (P < .05) bedding sources. In addition, corn stover and oat straw had significantly higher potassium than barley straw, control, and wheat straw (P< .05). Phosphorus also tended to be highest in corn stover (P= .0960). When a comparison was made between manure and compost nutrient composition, potassium levels became strikingly obvious. This can be attributed to the concentration of nutrients that occurs in the composting process.

Table 7. Compost nutrient characteristics.

	Control	Barley	Oats	Stover	Wheat	P Value
Dry Matter, %	77.62	78.37	75.50	76.00	75.2	0.33
Ammonia-N, ppm	150.35	131.2	167.87	187.7	58.85	0.09
Nitrogen, %	0.93^a	0.84^b	0.97^a	1.00^a	0.82^b	0.03
Phosphorus, %	0.39	0.35	0.38	0.42	0.34	0.10
Potassium, %	0.78^b	0.84^b	1.00^a	1.04^a	0.75^b	0.00

[ab]Values with differing superscripts are significant.

Implications

Although significant differences were not detected in animal performance or nutrient composition of fresh manure and bedding pack, composted manure nutrient analysis suggests corn stover and oat straw may be the superior bedding sources for retaining nutrients. Further research will have to be conducted to determine the implication of these findings and the practicality of using bedding as a tool to retain nutrients from feedlots.

Literature Cited

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