Effect of Hay Feeding Methods on Hay Waste and Wintering Costs

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Round hay bale feeding methods to include rolling bales out on the ground, shredding bales with a PTO driven bale processor, and feeding bales in a tapered-cone round bale feeder were evaluated. Feeding cows with a tapered-cone round bale feeder improved cow growth performance with less hay. In the economic model, a tapered-cone feeder design lowered equipment cost, feeding time and overall wintering cost.

Summary

The effect of hay feeding method on cow performance and economics were evaluated using 144 three to ten year old beef cows at the Dickinson Research Extension Center. Methods evaluated included 1) rolling round bales out on the ground, 2) a PTO driven round bale processor that shreds round bales into windrows , and 3) a tapered-cone round bale feeder engineered with a center tapered cone creating a manger around the inner circumference of the feeder. Gestating cows were fed for a period of 58 days to document feed waste, cow performance (weight gain, ultrasound fat depth change, body condition score change and hay intake), labor inputs, and feeding time, which were subsequently used to develop an economic analysis.

The tapered cone feeder increased ending weight (P=.011), rib and rump fat depth change (P=.08 and P=.033), ending body condition score (BCS) (P=.024), and reduced hay consumption (P=.002). While statistical significance for cow gain, ADG and BCS change were not significant, differences observed also suggest a trend favoring the tapered-cone round bale feeder.

In the economic analysis model, which was developed for 100 and 300 head cow herd sizes, feeding with a tapered-cone round bale feeder offered substantial cost savings per cow arising from lower hay consumption and reduced equipment operating time. Feeding costs per cow in the 100 head herd for rolling out bales, shredding bales with a processor and feeding bales in a tapered-cone feeder were $97.99, $107.44, and $85.36, respectively. When costs were projected for a 300 head cow herd, rolling out bales, shredding bales with a processor and feeding bales in a tapered-cone feeder were $97.80, $102.48, and $85.36, respectively. Using a PTO driven bale processor to shred bales into windrows before feeding was the most expensive due to higher equipment ownership cost and higher hay intake per cow compared to the tapered-cone bale feeder. Rolling bales out on the ground or shredding into windrows with a bale processor increased hay consumption and winter feeding cost without enhancing cow performance.

Introduction

Winter feeding cost makes up a large portion of production costs for North Dakota beef cattle producers (Hughes, 1999) and is the single largest variable influencing profitability (Miller, et al., 2001). Over the last five years, winter feed costs averaged $144 per head for producers participating in North Dakota's IRM program.

In most cases, hay makes up the largest portion of this winter feeding cost. A windshield survey of North Dakota beef cattle operations over the past three years indicates that the majority of this hay is put up in the form of large round bales. Numerous methods exist to deliver and feed hay stored in round bales to cattle during the winter. Some of the more common methods of feeding include rolling bales out on the ground, feeding bales in a bale feeder, or using a bale processor to chop the bale and feed in a windrow.

Data recently published by Michigan State University (Buskirk et al., 2003) suggests feeder type and animal behavior can influence the amount of hay wasted by beef cattle. Buskirk et al. (2003), reported losses losses of 3.5% (tapered cone), 6.1% (ring), 11.4% (trailer) and 14.6% (cradle feeder). A review of the literature indicates hay waste can be high ranging from 20 to 45% (Belya et al., 1985; Bell and Martz, 1973). Hay processors have gained acceptance by a large number of beef cattle producers for several reasons. First of all, they can reduce the overall investment in machinery compared to tub grinding and feeding hay with a mixer wagon. While bale processing machines do not have mixing capabilities, they can be used very effectively for filling bunks. Secondly, many people believe hay waste is less with this feeding method (compared to feeding on the ground or in a feeder), especially with 'stemmy' hays since the stems are chopped and essentially mixed in the windrow as the cattle are fed, eliminating or reducing the sorting problems which can occur. As herds become larger, producers have sought additional mechanized methods of feeding, however, available data to date has not compared the use of a hay processor to either rolling hay out on the ground or feeding hay in a tapered-cone round bale feeder.

The objective of this study was to compare feed waste, labor inputs, wintering cost, cow performance, and to develop a wintering economic analysis of the three methods.

Materials and Methods

One hundred forty-four crossbred cows with an average initial weight of 1320 pounds were used in this hay feeding methods/economic analysis study. Cows were divided into 12 groups with 12 cows assigned randomly to each of twelve five acre wintering lots located at the Dickinson Research Extension Center's ranch headquarters, Manning, North Dakota. A total 48 cows were assigned to each of the three treatments, which were replicated four times.

Hay Feeding Treatments Evaluated:

1. Round bales fed by removing the strings and rolling the bale out on the ground

2. Round bales shredded on the ground with a PTO driven bale processor

3. Round bales fed by placing the bale in a tapered-cone round bale feeder

Cows in the study were weighed, visually condition scored , and measured for fat depth using real-time ultrasound at the beginning, middle, and end of the study. Fat depth measurements are taken 3 inches distally from the midline between the 12th and 13th ribs and at a rump location medially on a line between the hook and pin bones. Quantity and quality of hay delivered and feeding time for each system was recorded. Individual bales were weighed and core sampled for subsequent nutrient analysis.

Data was analyzed using the statistical analysis system (SAS, 1996).

Feed Delivery Based on Dry Matter Intake Estimate

Forage fed was a mixed hay comprised largely of crested wheatgrass and bromegrass hays with a lesser contribution of alfalfa (20%). Proximate analysis for the forage fed is shown in Table 1. For the purposes of dry matter intake (DMI) prediction, the hay was estimated to contain a net energy value of approximately 1.146 Mcal/kg (1.07, 1.14, and 1.31 Mcal/kg for crested, brome and alfalfa hays, respectively). Based on the most current equation for predicting DMI among second/third trimester beef cows (NRC, 1996), initial DMI was estimated using the following formula: $DMI = (SBW^{0.75} \times (0.04997 \times NEm^2 + 0.04361)/ NEm)$ where $SBW^{0.75}$ is shrunk body weight (weight, kg x .95) to the 0.75 power, and NEm is the net energy value of diet for maintenance expressed in Mcal/kg. The DMI value is further adjusted for temperature, mud and postcalving milking ability of the gestating cow. Visual BCS and ultrasound fat depth measurements were taken at the start, middle and end of the feeding study. Hay delivery to each feeding method was adjusted as needed to maintain similar body condition across treatments without visible waste.

Accounting for Unutilized Feed Energy Delivered

Based on pounds of hay delivered (energy delivered), as prescribed by the prediction formula, initial and final visual body condition score, fat depth measurement (quantitative energy reserve change), cow body weight change (shrunk weight gain), conceptus weight (fetal and associated uterine tissues), and adjustment for North Dakota's environment (+16%), the quantity of energy consumed versus energy delivered within each hay feeding treatment was predicted. Thus, accounting for unutilized feed energy delivered (waste).

Economic Analysis of Winter Feeding Methods

Production measurements and efficiency, time required for feeding, and equipment and machinery inputs and depreciation were used to conduct an economic analysis of the feeding methods tested for 100 and 300 head herd sizes, which represent two typical operation sizes in North Dakota. The economic model assumed a winter feeding period of 135 days and hay in the model was priced at $42.50/ton. The round bale feeders were priced at $800.00 each and fed 13 cows. The round bale processor cost $15,000. It was assumed bale processor cutting flails would be replaced every 2,500 bales at a charge of $250 including labor. Tractor expenses were based on a 110 horsepower unit in all treatments and allocated based on typical use in other farm activities of which winter feeding is one of those activities (Lazarus and Selley, 2002). Operation and ownership costs were $27.00 per hour which included a $7.00 per hour labor charge. Based on feeding time measured for each hay feeding method, tractor time allocation for filling the round bale feeders was calculated to be three minutes per bale and 5 minutes per bale for the bales either rolled out on the ground or shredded with the PTO driven bale processor.

Results and Discussion

The tapered-cone bale feeder increased ending weight (P=.011), rib and rump fat depth change (P=.08 and P=.033), ending BCS (P=.024), and decreased hay consumption (P=.002) (Table 2). While cow gain (P=.19) and BCS (P=.27) change were not significant, differences observed suggested a trend also favoring the tapered-cone round bale feeder.

Positive change in both rib and rump fat depth using the tapered-cone round bale feeder, compared to the other feeding methods, suggests the source of the added weight was largely due to change in external fat cover. These data also suggest that nutrient availability was preserved using the new style round bale feeder as body condition was maintained while feeding significantly less hay (P=.002). Placing forage on the ground for the cows to pick up in the roll out and shredded bale processor systems results in some degree of trampling, which is virtually unavoidable, and the trampled material may be finer pieces of leaf and stem which may be higher in nutrient quality than other 'stemmier' portions of the hay.

In this study, waste was not physically weighed, however, the feeding grounds were evaluated prior each days new feeding and determined to be cleaned up adequately. Variation in fat depth measured between hay feeding methods (Table 2), suggests that to attain the same fat depth across treatments hay delivery to the groups fed on the ground (bale rollout and shredded) would have required more energy supplied from the hay. Hay delivery in these two treatments was increased slightly but not enough to provide sufficient energy to increase fat depth to equal that of the cows fed with the tapered-cone bale feeder.

Forage analysis of bales that were core sampled prior to feeding is shown in Table 1. Analysis results for dry matter, ash, crude protein, neutral detergent fiber(NDF), calcium, phosphorus, invitro dry matter digestibility, and invitro organic matter digestibility did not differ among treatments, however, acid detergent fiber (ADF) was higher for the tapered-cone. In Table 3, the amount of hay prescribed in the DMI prediction formula is compared to the amount of hay actually fed to each treatment. By subtraction, more or less hay consumption for either rolling out bales, shredding bales or feeding bales in a tapered-cone feeder was +3.65, +2.65 and -0.95 pounds per day, respectively. The additional hay delivered without a corresponding increase in cow body condition (ultrasound fat depth) was considered to be waste.

The value of waste in this investigation was defined in an economic analysis of the feeding systems summarized in Table 4. Hay conservation resulting from use of the tapered-cone round bale feeder figured heavily in the final economic analysis of the three hay feeding systems. Use of the tapered-cone round bale feeder offered substantial cost savings in two ways. First, cows in this group tended to consume less daily feed and the system required less equipment operating time. Feeding costs for shredding and rolling out bales were similar, however, shredding into windrows before feeding was the most expensive due to higher equipment ownership cost. Cost savings per cow using the tapered-cone round bale feeder compared to the bale processor were $22.08 and $17.12 respectively, for the 100 and 300 cow herds. When the tapered-cone bale feeder was compared to rolling bales out on the ground, cost savings per cow using the tapered-cone feeder of $12.63 and $12.44 were realized for the 100 and 300 head cow herds, respectively.

Processing hay for range cows with a bale processor increased the cost of feeding without enhancing animal performance. These results indicate that the method in which round bales are fed could reduce the amount feed required to winter cows thereby reducing wintering costs. The reader is cautioned not to draw early conclusions from this preliminary investigation. Our research team plans to repeat the investigation in subsequent years adding quantitative measurement and nutrient analysis of physical waste.

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Table 1. Forage Analysis.

	System			
	Round Bale Rollout	PTO Driven Round Bale Processor	Tapered-Cone Round Bale Feeder	P-Value
Dry Matter, %	95.2	94.9	95.1	.47
Ash, %	9.0	9.2	8.9	.12
Crude Protein, %	14.6	14.4	14.6	.87
ADF, %	38.9[a]	39.3[a]	40.7[b]	.008
NDF, %	53.9	54.6	53.1	.81
Calcium, %	1.1	1.0	1.0	.92
Phosphorus, %	.23	.22	.22	.80
IVDMD, %	59.9	58.1	59.2	.39
IVOMD, %	58.1	56.2	56.7	.20

Table 2. Bale feeding methods: cow gain, fat depth change, condition score change, and hay efficiency.

	Bale Roll Out	Bale Processor	Rd. Bale Feeder	P-Value
No. Cows	48	48	48	
Days Fed	58	58	58	
Starting Wt., lb.	1319	1305	1337	.25
End Wt., lb.	1361[a]	1365[a]	1412[b]	.011
Gain, lb.	42	60	75	.19
ADG, lb.	.72	1.04	1.29	.20
Ultrasound Fat Depth:				
Rib Fat - Start[a]	.503	.495	.543	.78
Rib Fat - End	.423	.443	.573	.13
Fat Depth Change	-.080[a]	-.052[a]	+.030[b]	.08
Rump Fat - Start[b]	.550	.548	.563	.92
Rump Fat - End	.750[ab]	.628[a]	.955[b]	.06
Fat Depth Change	+.20[ab]	+.08[a]	+.392[b]	.033
Body Condition Score[c]				
Start	5.38	5.44	5.54	.51
End	5.58[a]	5.54[a]	6.08[b]	.024
Change	+.20	+.10	+.54	.27
Hay/Cow, lb.	1795[a]	1761[a]	1524[b]	.002
Hay/Day, lb.	30.9[a]	29.9[a]	26.3[b]	.0004

[a] Backfat measurement was taken 3 inches distally from the midline between the 12th and 13th ribs.
[b] Rump fat measurement was taken medially on a line between the hook and pin bones.
[c] 1 to 9 scale (1 = extremely thin; 9 = obese)

Table 3. Unaccounted (As Fed) Forage Based on Dry Matter Intake Prediction (NRC, 1996)[a].

	System		
	Round Bale Rollout	PTO Driven Round Bale Processor	Tapered-Cone Round Bale Feeder
Hay Required/Cow, lb.	27.25	27.25	27.25
Hay Fed/Cow, lb.	30.90	29.90	26.30
Unaccounted Forage: waste, lb.	3.65 lb. more forage than predicted	2.65 lb. more forage than predicted	0.95 lb less forage than predicted

[a] *DMI* = $(SBW^{0.75} \times (0.04997 \times NEm^2 + 0.04361)/NEm)$ where $SBW^{0.75}$ is shrunk body weight (weight,kg x .95) to the 0.75 power, and NEm is the net energy value of diet for maintenance expressed in Mcal/kg. Requirement was increased additional 16% to account for North Dakota's environment.

Table 4. Hay Feeding Method Cost Comparison.

	System		
	Round Bale Rollout	PTO Driven Round Bale Processor	Tapered-Cone Round Bale Feeder
Hay consumed/day, lb.	30.9	29.9	26.3
Bales fed, number [cost][a]			
100 cow herd	417 [$8,861]	404 [$8,585]	355 [$7,544]
300 cow herd	1,251 [$26,584]	1,211 [$25,755]	1,065 [$22,631]
Equipment[b]			
100 cow herd	------------	$1,250	$513
300 cow herd	------------	$2,263	$1,538
Tractor operation[c]			
100 cow herd	$938	$909	$479
300 cow herd	$2,815	$2,727	$1,438
Total non-hay expense			
100 cow herd	$938	$2,159	$992
300 cow herd	$2,815	$4,990	$2,976
Total expense			
100 cow herd	$9,799	$10,744	$8,536
300 cow herd	$29,399	$30,745	$25,607
Cost per cow			
100 cow herd	$97.99	$107.44	$85.36
300 cow herd	$97.80	$102.48	$85.36
Hay as % of total cost			
100 cow herd	90.4	79.9	88.4
300 cow herd	90.4	83.8	88.4

[a] 1,000 lb bales were fed over a 135 day period. Cost per bale is $21.25 ($42.50 per ton).

[b] Each bale feeder cost $800 and fed 13 cows. Bale feeders were depreciated over 12 years. The bale processor cost $15,000. It was depreciated over 12 years for the 100 cow operation and 7 years for the 300 cow operation. Cutting flails were replaced every 2,500 bales at a total replacement cost of $250 including labor charge.

[c] A 110 HP tractor is used regardless of system; model expense referenced from Lazarus and Selley (2002). Ownership expenses calculated assuming the tractor experiences typical use in other farm operation activities. Operation and ownership costs are $27 per hour including a $7 per hour labor charge. Tractor time is three minutes per bale for the bale feeder and five minutes per bale for roll out and bale processor systems.