Comparison of Hay or Round Bale Silage as a Means to Conserve Forage[1]

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Introduction

Conservation of forage during the summer for deferred use is a common production practice for beef cattle enterprises. Pasture forage production is not always adequate to meet beef cow intake or nutrient requirements. Conservation of forage provides feed and nutritional resources to meet beef cow nutritional requirements during annual seasonal deficits in pasture forage production to maintain adequate cow productivity.

Florida's climate makes conserving forages for later feeding challenging. Forage for hay production must be harvested when the humidity is low to ensure optimal drying conditions. Additionally, Florida growing conditions make conserving the quality of forage difficult, since frequently it must be harvested when it has matured past its nutritional peak. Scientists are exploring alternative methods of forage conservation suited to Florida's challenges. Extensive work with the development and utilization of round bale silage (RBS) has previously been examined by Kunkle (2003). Round bale silage offers an alternative method of forage harvesting and storage to traditional hay harvest and storage. Traditional hay harvest systems require optimal cutting, drying, and baling weather conditions. The use of round bale silage overcomes several of the challenges to hay production in Florida and offer an attractive compliment to traditional hay harvest systems.

Certainly, RBS offers several advantages. A primary advantage is that RBS can mitigate adverse weather and drying conditions for hay production that frequently occur in Florida during the summer (Figure 1). Incorporation of a RBS system increases the flexibility of the forage harvest window. Sequential days of dry weather are not required for the conservation of forage in the RBS system. This flexibility allows for the timely harvest of forages to capture forage nutrients before they are lost due to maturity or weathering. Additionally, RBS does not require as much drying time as hay; therefore, less plant material is lost due to processing and handling. Appropriate preservation dry matter targets for hay (approximately 85%) and RBS (approximately 50%) should be utilized. Excessive moisture in either hay or RBS will increase the opportunity for spoilage and ultimately decrease the quality and consistency of the conserved forage. Because it protects silage from weathering, an RBS system may retain more of the nutrients in the forage than a traditional system. Finally, RBS-conserved forage maintains its quality out of doors, thus no hay barn structures are required.

Application

A demonstration was conducted at the Santa Fe-Boston Farm Beef Research Unit located in northern Alachua County Florida. A 50-acre Tifton-85 Bermudagrass field was divided into two 25-acre sections. One section was managed to produce hay only. Forage was harvested as large

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round hay bales (5-foot diameter) as growing conditions and weather permitted. The other section was managed on a 4-week harvest schedule. Forage was harvested and stored as large round hay bales when weather/drying conditions permitted. When weather did not allow for harvest as hay, forage was harvested and stored as RBS. The hay only section was fertilized four times (1–90 lb N/acre, 3–80 lb N/acre) from April through August; the hay-RBS section received five applications of fertilizer (1–90 lb N/acre, 3–80 lb N/acre, 1–68 lb N/acre) because an additional forage harvest occurred.

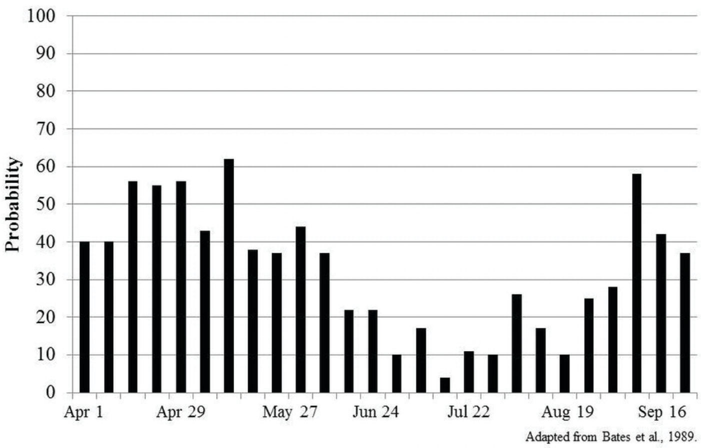

Figure 1. Probability of three consecutive dry days each week during the spring and summer.
Credits: Adapted from Bates et al. (1989)

Hay production typically required 3 to 4 days of drying time with 1 to 2 rakings to facilitate dry-down of the forage. The RBS was baled in a similar manner to dry hay using a large round baler. It was preserved with an Anderson in-line hay wrapper. Production of RBS utilized a 3- to 4-hour wilting time between cutting and baling and no raking. Bales for RBS were wrapped within 2 hours of baling. Hay and RBS bale weights and core samples were collected on every 10th bale produced on the day of harvest. Analysis of hay and RBS samples was performed by Dairy One (Ithaca, NY) NIRS analysis. This analysis provided detailed information about bale dry matter, protein, total digestible nutrient, fiber fractions, and other nutrients. Bale weights were obtained after baling, and either prior to storage as hay or RBS. Total number of bales was recorded at each harvest to calculate total pounds of forage harvested for each system.

Outcome

More cuttings of forage were taken from the hay-RBS field, which was managed to remove forage on a regular interval compared to the hay field (Table 1). The increase in the number of cuttings resulted in an increased total number of bales, total wet forage harvested, and total forage dry matter harvested from the hay-RBS compared to the hay-only production system. The hay-RBS section included one cutting of forage that was harvested as hay. Mean bale weight produced from the hay-RBS section was 42% greater than mean bale weight from the hay section. Forage dry matter was very different between the two harvest sections because of the large portion of forage harvested as RBS. Hay section bale dry matter was 45.7 units greater than bales produced from the hay-RBS section. Mean bale crude protein (CP) and total digestible nutrient (TDN) % were greater for forage harvested from the hay-RBS section compared to the hay section. When expressed on a dry matter basis, mean bale weight and bale TDN supply was greater for the hay section than the hay-RBS section. However, mean bale CP amount did not differ between the two harvest systems.

When the forage conservation method (hay vs. RBS) was examined, mean bale weight was greater for RBS than for hay bales (Table 2). This is a result of the lower dry matter percentages associated with RBS compared with hay. Additionally, CP and TDN percentages for bales produced during the summer harvest period were greater for RBS bales than for hay bales. In contrast, greater mean hay bale dry matter yield and TDN yield occurred in hay bales compared to hay RBS, but CP yield did not differ. The improvement in hay CP and TDN percentages between Table 2 and 3 occurs because the hay described in Table 3 includes hay produced from the hay-RBS section. Hay bales from the hay-RBS section were slightly greater in quality compared to hay only because of the regular harvest schedule that helped to capture forage quality through managing forage maturity. Management of forage maturity mitigates the increases in fiber fractions, decrease in protein concentration, and increase in stem:leaf ratio as grasses grow and mature. A common misconception is that the ensiling process that RBS undergoes improves the nutritive value of the RBS product. In fact, the nutritive value of the forage is set when the forage is harvested; wrapping RBS just preserves what is present in the forage.

Any forage conservation system will benefit from analysis to quantify the economic parameters of hay and RBS production. This analysis should include comparisons between hay and RBS cost of production and the cost benefit to producing and storing high-quality stored forage. Table 3, using inputs from the demonstration reported in Table 2, presents a cost comparison between hay and RBS production. However, in this example forage is conserved exclusively as either hay or RBS. The calculations and comparisons between hay and RBS in the example are sensitive to the dry matter percentage of the RBS and estimated storage loss difference between hay and RBS (Table 5). Likewise, the different production inputs for hay and RBS (number of raking, baling costs, and fertilizer applications) and differing costs for these production inputs will drive production costs differences (Table 6). Additionally, the number and size of hay or RBS bales produced will affect total production costs; more and larger bales spread production costs over more output, thus decreasing the production costs per unit produced (i.e., tons of forage, bales).

Summary

Harvesting forage as round bale silage works very well as an alternative to traditional hay harvest. Forage harvest can occur on a regular schedule to optimize forage quantity and quality. To optimize the investment in round bale silage production, harvest forage at its nutritional peak to capture superior quality and to increase production. Additionally, the decreased storage loss associated with round bale silage improves the economic viability of round bale silage as a complement or alternative to hay production.

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Table 1. Effect of forage production management system on conserved forage production and quality.

Item	Hay-Only Field	Hay-RBS Combination Field
Number of cuttings	3	5
Number of bales produced	259	479
Total harvest, lbs as fed	219,123	709,131
Total harvest, lbs dry matter	202,743	312,728
Mean bale		
Wet weight, lbs	847	1,470
Dry matter, %	92.5	46.8
Crude protein, %	10.1	12.9
Total digestible nutrients,%	54	57
Dry matter, lbs	783	645
Crude protein, lbs	79	82
Total digestible nutrients, lbs	418	369

Table 2. Effect of hay or round bale silage preservation method on the characteristics of representative bales

Item	Hay	RBS
Mean bale		
Wet weight, lb	824	1,556
Dry matter, %	92.5	41.3
Crude protein, %	10.4	13.1
Total digestible nutrients,%	54	57
Dry matter, lbs	769	638
Crude protein, lbs	78	83
Total digestible nutrients, lbs	416	365

Table 3. Cost comparison of the production and storage of hay or round bale silage forage.

Inputs and Production		Hay	Round Bale Silage
Field Size	acres	25	25
# of cuttings		3	5
# of rakings		6	5
# of bales produced		259	479
Average bale weight	lbs	847	1556
# of fertilization applications		4	5
Forage dry matter (DM)	%	93%	41%
Forage total digestible nutrients (TDN)	%	54%	57%
Forage crude protein (CP)	%	10%	13%
Estimated Storage Loss[1]	%	28%	5%
Total as-fed production	lbs	219,373	745,324
Total DM production	lbs	202,920	305,583
DM TDN produced	lbs	109,577	174,182
DM CP produced	lbs	20,292	39,726
Total as-fed available	lbs	157,949	708,058
Total DM available	lbs	146,102	290,304
TDN available	lbs	78,895	165,473
CP available	lbs	14,610	37,739
Production Economics		**Hay**	**Round Bale Silage**
Total baling cost[2]	$	$ 7,670.55	$ 12,143.10
as-fed cost per acre	$/acre	$306.82	$485.72
DM cost per acre	$/acre	$331.70	$ 1,184.69
As-fed forage cost	$/ton	$69.93	$32.58
Dry matter forage cost	$/ton	$75.60	$79.48
As-fed bale cost	$/bale	$29.62	$25.35
Dry matter bale cost	$/bale	$32.02	$61.83
Cost of DM	$/lb	$0.04	$0.04
Cost of TDN	$/lb	$0.07	$0.07
Cost of CP	$/lb	$0.38	$0.31
Final Forage Economics (includes spoilage loss)		**Hay**	**Round Bale Silage**
As-fed forage cost	$/ton	$97.13	$34.30
Dry matter forage cost	$/ton	$105.00	$83.66
As-fed bale cost	$/bale	$41.13	$26.69
Dry matter bale cost	$/bale	$44.47	$65.09
Cost of DM	$/lb	$0.053	$0.042
Cost of TDN	$/lb	$0.097	$0.073
Cost of CP	$/lb	$0.525	$0.322

[1] Estimate from Table 5.
[2] Prices found in Table 6.

Table 4. Hay and round bale silage cost comparison worksheet.

Inputs and Production		Hay		Round Bale Silage
Field Size	acres			
# of cuttings				
# of rakings				
# of bales produced				
Average bale weight	lbs			
# of fertilization applications				
Forage dry matter (DM)	%			
Forage total digestible nutrients (TDN)	%			
Forage crude protein (CP)	%			
Estimated storage loss	%			
Total as-fed production *# of bales* x *average bale weight*	lbs			
Total DM production *total as fed production* x *forage DM %*	lbs			
DM TDN produced *total DM production* x *forage TDN %*	lbs			
DM CP produced *total DM production* x *forage CP %*	lbs			
Total as-fed available *total as fed production* x *(100-storage loss %)*	lbs			
Total DM available *total DM production* x *(100-storage loss %)*	lbs			
TDN available *DM TDN produced* x *(100-storage loss %)*	lbs			
CP available *DM CP produced* x *(100-storage loss %)*	lbs			
Production Economics		**Hay**		**Round Bale Silage**
Total baling cost [2] ((# cuttings *((# cuttings* x *(mowing cost, $/acre* x *acres)) + (# rakings* x *(raking cost, $/acre* x *acres)) + ((fertilizer application cost, $/acre* x *acres)+(fertilizer cost, $/acre* x *acres)* x *# of fertilizer applications)* + *(baling cost, $/bale* x *# of bales) + (bale moving cost, $/bale* x *# of bales)*	$			
As-fed cost per acre *total baling cost ÷ # of acres*	$/acre			
DM cost per acre *as fed cost per acre ÷ forage DM%*	$/acre			
As-fed forage cost *total baling cost ÷ (total as fed production ÷ 2000)*	$/ton			
Dry matter forage cost *total baling cost ÷ (total DM production ÷ 2000)*	$/ton			
As-fed bale cost *total baling cost ÷ # of bales*	$/bale			
Dry matter bale cost *as fed bale cost ÷forage DM %*	$/bale			
Cost of DM *total baling cost ÷ total DM production*	$/lb			
Cost of TDN *total baling cost ÷ lbs DM TDN produced*	$/lb			

Cost of CP *total baling cost ÷ lbs DM CP produced*	$/lb	___________		___________
Final Forage Economics (includes spoilage loss)		**Hay**		**Round Bale Silage**
As-fed forage cost *total baling cost ÷ (total as fed available production ÷ 2000)*	$/ton	___________		___________
Dry matter forage cost *total baling cost ÷ (total DM production ÷ 2000)*	$/ton	___________		___________
As-fed bale cost *as fed bale cost ÷ (100-storage loss %)*	$/bale	___________		___________
Dry matter bale cost *DM bale cost ÷ (100-storage loss %)*	$/bale	___________		___________
Cost of DM *total baling cost ÷ total DM available*	$/lb	___________		___________
Cost of TDN *total baling cost ÷ total DM TDN available*	$/lb	___________		___________
Cost of CP *total baling cost ÷ total DM CP available*	$/lb	___________		___________

[1] Estimate from Table 5.
[2] Prices found in Table 6.

Table 5. Estimated forage storage loss for different storage methods.[1]

Storage method	Estimated % loss
Bare ground with no cover	28
On gravel with no cover	24
Bare ground under tarp	13
On gravel under tarp	9
Under roof with no sides	8
Inside building	5
Bare ground with plastic wrap (round bale silage)	5

[1]Adapted from Collins et al.

Table 6. Custom rate prices for hay and round bale silage production.[1]

Action		Hay	Round Bale Silage
Mowing/conditioning	$/acre	$12.40	$12.40
Raking	$/acre	$5.65	$5.65
Baling	$/bale	$9.80	$11.00
Moving round bales to storage	$/bale	$2.90	$2.90
Fertilizer application	$/acre	$4.15	$4.15
Fertilizer cost	$/acre	$25.00	$25.00

[1] Adapted from Iowa State University Farm Custom Rate Survey A3-10
[2] Includes the cost of plastic wrap using a tube wrapper.
[3] Fertilizer cost is highly variable based on soil test, production needs, and choice of fertilizer applied.